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Dephosphorisation in the Ladle

Mr. Gordon M. Yocom, the steelworks superintendent of the Benwood plant of the Wheeling Steel Corporation of West Virginia, merits the congratulations of the metallurgical world for having successfully developed the dephosphorisation of acid Bessemer metal by ladle treatment. We have only been able to make a relatively short abstract of his explanatory Paper, which is printed elsewhere in this issue, because much of it relates to the production of wrought materials. The reduction of phosphorus in a quarter of a million tons from 0.09 to 0.03 per cent. by the means described is indeed a creditable achievement. So far as this country is concerned, the acid Bessemer process is not very extensively practised, but in its modified forms it is widely used by the foundries for the production of steel castings. The main feature of interest in this field can be considered from two angles. The first and most important is whether the new process would permit of the use of higher-phosphorus and so cheaper raw materials in the cupola. The second is the hypothetical case where the raw materials are yielding a composition which is so close to the upper limit of specified phosphorus content as to cause some embarrassment to the management.

In studying this Paper, it is essential to bear in mind the problem which the author set out to solve. Primarily, he is charged with the production of low-carbon rimming steel and the like. He uses a mixture of liquid blast-furnace metal and cupola iron, and sometimes the former would run dangerously high in phosphorus. He has solved his problem of producing *rimming steel*, but such material would be quite unsuitable for steel castings, as its characteristics are a solid outer shell and a porous core. Yet Mr. Yocom has disclosed a process which is capable of development. He has wisely outlined its drawbacks, which superficially condemn its application to the general run of steel castings, but, again, the original object of the experiments—the production of rimming steel—must be borne in mind. In the second hypothetical case we have cited—that of a quite mild reduction in phosphorus to ensure the material being well within the specificational tolerances—a suitable technique seems capable of development.

The author rightly stresses the nature of the refractory lining to be used for the ladle in which the very rapid reaction takes place. Amongst the British steel foundries practising the soda-ash desulphurising process, a special and very successful technique has been developed for ladle linings, and although one is dealing here with liquid iron and not steel, yet for any early experiments that may be the consequence of Mr. Yocom's researches, one might do worse than use the same material, carrying as it does a percentage of neutral refractory. The dephosphorising mixture should be capable of being reproduced on this side of the Atlantic, and the possibility exists of its application to the rotary melting furnace, provided that the plant possesses the best available, rapid and complete slagging facilities. Bearing in mind some advice once tendered to us by Mr. Arthur Brearley, "that the ladle is not the proper place in which to make steel," then the combination of an acid rotary furnace and a rapid dephosphorising process—should such a method be possible—certainly overcomes the objection rightly raised by Mr. Brearley, and opens up a vista of great commercial potentiality. Moreover, if, as Mr. Yocom points out, the process does not work with a carbon content higher than 0.20 per cent., then recarburisation could follow dephosphorisation and, associated with "killing," it would place the material in a condition well suited for the production of steel castings.

There is still the factor that, in the process disclosed, the dephosphorising mixture is fed as a powder into the stream of liquid steel as it leaves the converter, and it may well be that the straight addition as a slag material would not effect the same result, though placing it at the bottom of the ladle would, we should imagine, be equally efficacious. However, should this stream-treatment be an essential, then its application to the acid rotary furnace would involve either the creation of a ladle technique or perhaps a duplex system. Finally, all the process has disclosed up to now is its proved practicability in the conditions operating in America and the germ of an idea well worth pondering over by British metallurgists controlling any acid process of steelmaking.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Acid-Resisting Cast-Iron Pots

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—At least one paragraph of the article appearing in your issue of February 13 under the heading, "Acid-Resisting Cast Iron," appears to call for comment. The paragraph in question suggests that perhaps foundries in this country have no equipment to make caustic pots in excess of 7 ft. 9 in. dia. Surely the foundry trade will not allow that to pass without challenge? It cannot be that the British foundry trade will allow the world to think for a single moment that anything over 7 ft. 9 in. is "too big."

A drawing on the desk at this office at the moment shows a caustic pot 9 ft. 2¼ in. dia. by 6 ft. deep, which was made in our foundry, and this is by no means the biggest we have made. It just happens to be the one most closely to hand.

It is not our intention to press the personal aspect. We know that other foundries have made bigger pots than we have. What is most important is that no false impression on matters of this kind should be allowed to take root, especially in the minds of potential buyers. In the lay mind there are already quite enough of these false impressions. A provincial daily newspaper, for instance, recently featured the casting of an 18-ton bed, asserting that this was a feat never before attempted. On the very day that this statement appeared a casting close on 40 tons was being cast in our foundry; but the lay mind will never know that.

Some local tube manufacturers had a similar interesting experience. By some transitional error, no doubt, foreign competitors sent a piece of tube to them which they boasted was the smallest tube in the world. The local firm thereupon made a tube small enough to go inside the so-called smallest, and sent the two of them back to the competitive firm without comment. Yes, in the words of the American, "this biggest and smallest business sure is dangerous ground."—Yours, etc.,

HUNT BROS. (OLDBURY), LIMITED.

Griffin Foundry,
Oldbury.
February 20, 1941.

Foundry Query

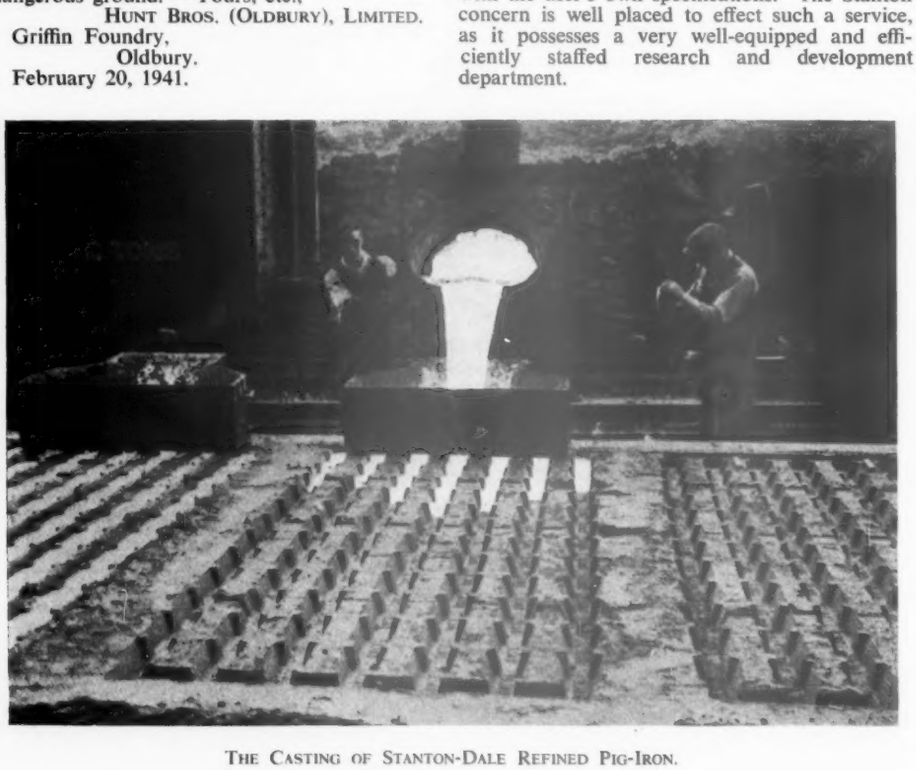
Sand for Stainless Steel Castings

A stainless-steel founder has experienced difficulties, especially in surface finishing, and has traced them to a bad quality of sand. It seems without doubt that the sand mixture is not sufficiently permeable for gas escape, and the sintering point is lower than the casting temperature of 1,700 deg. C. or more. The foundry does not believe that this problem can be solved merely by using only new sand and mixing a binder with it. Rather is it thought necessary to find a sand with a high melting point, but such a sand would, of course, need a higher percentage of binder than an ordinary sand because its clay content will be poorer. Therefore the production of a synthetic sand becomes necessary.

Technical developments in stainless steel in the future will probably increase the pouring temperatures. All other steel founders face the same difficulties—what kind of synthetic sand has to be produced, and what qualities are required in the original sand used as the starting material? Any assistance our readers can give will be welcomed by the inquirer.

A Development in Refined Pig-Iron

Refined iron is assuming increasing importance in grey-iron foundry practice owing to its suitability for replacing hematite for the making of engineering and high-duty castings. The Stanton Ironworks Company, Limited, have taken over additional furnaces for the making of Stanton-Dale refined pig-iron and are following the practice of casting small pigs, as will be seen in our illustration. Fletcher was probably the first to point out the difficulties of blending high-phosphoric pig with steel scrap, and the use of suitable refined iron overcomes such troubles. Properly used the test-bars from the castings should yield between 16 and 20 tons per sq. in. tensile strength. There are seven standard grades of Stanton-Dale pig-iron, yet despite this analyses can be compounded to conform with the user's own specifications. The Stanton concern is well placed to effect such a service, as it possesses a very well-equipped and efficiently staffed research and development department.



THE CASTING OF STANTON-DALE REFINED PIG-IRON.

Random Shots

The receipt of a calendar from Mr. Sims, of Sydney, Australia, reminds "Marksman" of a good story against himself, of which Mr. Sims was the unfortunate victim. Whilst in England he had expressed a desire to have a look round the countryside, and "Marksman" volunteered to act as his guide. Having just read a delightful new book by Philip Gosse, which sang the praises of Sussex in general and a village, "Withybeds" by name, in particular, it was decided that Withybeds should be the goal of the journey. According to the author, it was the only really unspoiled village left in Sussex, a truly rural backwater, complete with rose-covered cottages and besmocked oldest inhabitant and an inn which saw no tourists year in and year out. Directions were given to a spot within a mile of the village. After that the author advised the reader to ask the way at a certain house "on the right, just by a white gate"; for if he were to give precise details the place would be besieged by all and sundry. This was the war cry, and the challenge was taken up, for "Marksman" professes never to have been beaten over finding his way around.

* * *

With car tuned up to concert pitch and Ordnance map in hand, off the party set. It was a lovely day and all seemed to go well. They had found the signpost which was the key-point in the directions. Turning up a narrow lane (which looked very promising), they eventually found the house on the right, and duly alighted to make the necessary inquiries. Imagine "Marksman's" feelings when the lady of the house replied, "Have you, too, been taken in by it? You're about the fiftieth party this week-end who has asked me the same question, and I'd like to wring Mr. Philip Gosse's neck!" It had at last become abundantly clear that the narrow turning was just another garden path and that "Marksman" was just another mutt who had been gently led up it, whilst Mr. Gosse basked in his lovely Sussex garden laughing up his sleeve!

* * *

However, it is only fair to add that within half a mile the party stumbled on a most delightful garden which was that day thrown open to the public in aid of the hospitals—so it can be hoped that Mr. Sims had, after all, a very pleasant memory to take back with him, for that garden was a joy to behold, and the day was about as perfect a summer day as England can on occasion produce.

* * *

Just Another Point of View

A lunatic was trying to hammer a nail into a wall, holding the head against the wall whilst hammering the point. Meeting with no success, he turned to his neighbour and said:

"Hi, Jimmy, they've made this nail the wrong way on."

"Nay, they haven't," replied his companion, after much scrutiny of the nail in question. "It's meant to go on the other side of the wall."

* * *

An Addition to Metallurgical Nomenclature?

"An *apparent* scab" is a term used in a recent article on acid-resisting cast iron from the user's point of view. So far in the foundry industry no one has had the courage to give a name to the ignoble practice of filling in holes with iron cement!

* * *

Mrs. Malaprop is sorry that she has been away so long, but she has been in bed with a nasty attack of gastronomical 'flu.

"MARKSMAN."

A Method of Rapid Dephosphorisation of Bessemer Steel*

By GORDON M. YOCOM†

At the Benwood Plant of the Wheeling Steel Corporation of Virginia during the past three years about 250,000 tons of low-phosphorus steel have been produced by a new process.

A low-phosphorus steel is required in certain grades because phosphorus is an effective hardener, by solid solution with the ferrite, and reduces the ductility of low-carbon steel. It is generally found that each 0.010 per cent. increases the yield point about 700 lbs. per sq. in. At about 0.070 per cent. P the adverse effect on ductility is so great that a reduction in carbon content is necessary. Tensile strength and elastic limit increase with phosphorus content. Resistance to impact increases up to 0.065 per cent. P, but above that decreases very rapidly. The effects of oxygen and nitrogen are injurious to certain properties of low-carbon steel, but frequently the bad effects of these elements and improper methods of processing have been attributed to phosphorus. Phosphorus is useful in high-strength steels, but harmful in steels when high ductility is required.

Phosphorus is present in iron and steel in the form of Fe_3P and is readily soluble in iron, but practically insoluble in slags. Oxidation is necessary before phosphorus can be removed from iron, and this is more readily accomplished at low than at high temperatures. Above about 1,315 deg. C. P_2O_5 is reduced by carbon, silicon and manganese, if present. P_2O_5 is readily soluble in basic slags and practically insoluble in acid slags. The presence of 30 per cent. SiO_2 is the upper limit at which a slag will take up P_2O_5.

In connection with the acid Bessemer process, a dephosphorising treatment is best applied to the blown metal, which at this stage contains no silicon and very little carbon. The slag on the metal in the converter at the end of the blowing period contains over 50 per cent. SiO_2. Obviously, this siliceous converter slag must be separated from the blown metal before a dephosphorising treatment with basic materials is attempted. The author has developed an inexpensive method for effecting this separation.

Iron and Slag Control for Dephosphorisation

The dephosphorising method devised requires a blown-metal temperature in excess of normal for the purpose of melting a dephosphoriser added in the cold state. Excess temperatures affect slag fluidity, and it was found that a silicon to manganese ratio of 2 to 1 coupled with young blowing was a minimum requirement for the production of the proper kind of thick slag. In the author's case a manganese content of about 0.50 per cent. is normal, but the silicon and manganese contents are adjusted to the requirements for producing the desired type of converter slag.

Iron Specification for Dephosphorisation

The silicon content of the iron used in connection with an unmelted dephosphorising addition required an upward adjustment of about 0.25 per cent. above the minimum of 1.00 per cent. for normal practice during regular operations. An increase of 0.35 to 0.50 per cent. Si is required on starting-up turns after the week-end shut-down period. This is in connection with small converters making 6- to 8½-ton heats. Larger vessels should be able to operate with a lower-silicon iron.

A mixture of 40 to 50 per cent. direct metal and 50 to 60 per cent. cupola metal is charged for each blow. The direct metal analyses: Si, 1.50 to 1.70 per cent.; Mn, 0.60 to 0.65; P, 0.085 to 0.095; S, 0.020 to 0.040 per cent. The cupola iron analyses: Si, 1.15 to 1.25 per cent.; Mn, 0.45 to 0.55; P, 0.090 to 0.100; S, 0.055 to 0.065 per cent.

This iron is desulphurised as required with soda ash. The cupola charge can be adjusted to produce an iron of high or low silicon content within several hours' time, to meet any drastic change in the composition or amount of direct metal. The cupola production can also be adjusted to melt any desired tonnage between 600 and 900 tons per day, and in this manner a further adjustment with the casts of iron can be made by varying the proportion of cupola iron used. The charge to each converter does not vary more than a few points either way from the following specification: Si, 1.40 per cent.; Mn, 0.55 per cent.; ratio, 2.5:1.

During the hot periods in the summer, when the humidity in the air is high, an upward adjustment in silicon and manganese is made, and during the dry, cold periods a downward adjustment.

The coke is of low sulphur content made up of a mixture of two cokes averaging about 0.75 per cent. S. The slag is slightly acid, to meet the requirements for road material, and the average volume is 1,000 lbs. per ton of iron.

Separation of Slag and Metal

After the vessel is turned down, a block of wood attached to a long rod is inserted in the nose of the vessel. The block is 4 in. by 4 in. square and slightly longer than the distance across the nose at a point a few inches above the pouring lip. A light rod is attached to the block at an angle sufficient to allow the slag man to stand far enough to one side to avoid the heat. The only manual labour required is the lifting of the block over to the inside of the nose and dropping it into place. The nose is kept built up to a U-shape at this point, to provide a shoulder for each end of the block to rest against when the vessel is in the pouring position. When the vessel is lowered to pour the blown metal into the ladle the thick slag floats forward against the block, which prevents the slag from entering the steel ladle.

Dephosphorisation

A complete separation of slag and metal having been effected in an inexpensive manner, the dephosphorisation proceeds very rapidly and uniformly from heat to heat without delays or interruptions in the cycle. The dephosphorising material is added to the stream of metal as it is being poured from the converter into the steel ladle. The mixture used consists of 50 per cent. impure lime (Calsifer), 30 per cent. roll scale (dried), and 20 per cent. flux (dried). This mixture is added in the cold state. Such a mixture when melted together to form a slag analyses as follows: CaO, 48 per cent.; Fe_2O_3, 28; SiO_2, 7; Al_2O_3, 7 per cent.

The dry mixture is held in a hopper and runs down a pipe shute directed toward the stream. The rate of flow of the mixture is controlled by a sliding valve at the bottom of the hopper. The flow is adjusted, manually, to coincide with the stream of metal. The blown metal is poured fast, then slow, alternately, to maintain the proper boiling action in the ladle. This reaction should be as vigorous as possible, but the metal should not be permitted to boil up over the ladle. This induces an action that causes a very intimate contact of slag and metal and reduces the phosphorus to the lowest degree. A mild reaction with the slag merely lying on top of the metal as a blanket results in a higher phosphorus content.

The addition of the mixture is begun immediately upon the appearance of the manganese boil from the first shovelful of ferro-manganese added. The ferro-manganese and mixture are added concurrently for a few seconds, the addition of the mixture continues for a few more seconds and is completed when about one-half of the blown metal has left the vessel. The mixture is added just as rapidly as the metal will take it up and melt it, and the operation is completed in about 30 secs. The phosphorus is reduced from 0.095 or 0.100 per cent. to 0.020 to 0.040 per cent. in that time. The slag is very thin and fluid and has a very low melting point, and after the ladle is filled the reaction subsides to a slight ebullition, and by the time the ladle has reached the pouring platform the slag has risen to the top and the reaction has ceased.

Ladle Linings

Experimental runs were made with both basic and neutral materials. These materials were rather high in initial cost and did not stand up long enough to justify the expense. There was some heat loss involved and a tendency to produce ladle skulls. They permitted a reduction in the amount of dephosphoriser required but the over-all costs were increased.

The chrome-brick and monolithic, plastic chrome linings withstood slag and metal attack while at temperatures over 1,510 deg. C. However, during the cooling periods between heats the temperature dropped to perhaps 1,370 deg. C., and in this range mechanical weakness developed, which caused early failure of the lining. This type of lining produced heavy ladle skulls, owing to heat losses. The extremely fluid basic slag washed out the joint material and there was sufficient heat loss to cause metal to freeze in the open joints with heats of normal temperature. This contributed to failure of the lining because of unsatisfactory joint patches.

The most satisfactory lining developed to date consists of a very hard-burned grade of dense clay brick set up with a thin buttered joint of a chrome-base material containing a vegetable bonding material. Sodium silicate cannot be used as a bond in this process. The dense, hard brick resists slag penetration, does not spall, and retains some heat. The joint material does not stand up with the brick but there is no tendency to leave skull metal in the joints of an otherwise clean ladle and satisfactory joint patches are obtained. This type of lining normally handles two to four regular heats followed by six to eight dephosphorised heats before being taken out of service for a patch. The ladle reaction of the dephosphorised heats causes an uneven attack of the lining and the thin sections are patched with a rather dry rammed mix of ground ganister and clay. Experiments are being made with a patching mortar made up of several neutral materials and a special binder. This may permit a reduction in the amount of dephosphoriser required for neutralising acid contamination.

Dephosphorising Materials

Many different mixtures of basic materials and fluxes will eliminate some phosphorus from the blown metal if the siliceous converter slag is removed. Generally speaking, those having the best dephosphorising effect attack the ladle lining to the greatest extent and those having

* Abstract of a Paper read before the American Institute of Mining and Metallurgical Engineers and printed in "Metals Technology."

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the least effect on the ladle lining usually eliminate the least phosphorus. The most desirable mixture is that which will remove the required amount of phosphorus at the lowest cost for both the mixture and ladle linings. The dephosphorising materials, being added in the cold state, must be convertible to a slag of low melting point in a very short time after it contacts the hot metal. Lime is the cheapest basic material but in its purer forms has a melting point of 1,925 deg. C. or possibly higher. The presence of small amounts of impurities such as silica or iron oxide lowers the melting point so that impure lime will frit at 1,400 deg. C. or less. The lime base used in the dephosphoriser is of an impure type and compares with a purer lime as shown in Table I. The Calsifer is brown in colour in the calcined form and is very dense and hard as compared with purer lime. It goes into solution more rapidly than the standard grade of pebble-size chemical lime because of the 4 per cent. of natural impurities present. This property is of sufficient value to overbalance the disadvantage of the high silica content. The iron oxide content is a distinct advantage for this process.

TABLE I.—*Comparison of Calsifer and Pure Lime.*

Impurities.	Calsifer (impure lime). Per cent.	Pure chemical pebble lime. Per cent.
SiO_2	1.83	0.36
Fe_2O_3	2.70	0.04
CaO	94.36	96.90
MgO	0.57	0.95
S	0.04	—
Ignition loss	1.10	1.75

The impure lime will resist slaking to a greater extent than pure pebble lime. The burned rock is crushed to pass through a ¼-in. mesh screen, and very few fines are produced. The small particle size is necessary because of the short duration of the ladle reaction.

Fluxes

The fluxes employed for obtaining the required fluidity of the lime and iron oxide mixture have varying effects on elimination of phosphorus, attack of the ladle lining, melting point, and slag fluidity.

Bauxite produced a slag having some effect on removal of sulphur, but the mixture was not entirely satisfactory as a dephosphoriser. Phosphorus was reduced to 0.050 or 0.060 per cent., but seldom below that figure. The material contained 53 per cent. Al_2O_3, 15 per cent. Fe_2O_3, 7 per cent. SiO_2, and 22 per cent. combined water. The high water content caused a foamy slag, thereby reducing the surface of contact between slag and metal, and less phosphorus was eliminated. The slag caused only minor attack of the ladle lining. An economical reduction in the water content of the crude ore would be required for its use in such a process. Mixtures containing 10 per cent. manganese ore and 10 per cent. bauxite reduced the phosphorus to 0.040 and 0.043 per cent.

Ilmenite ore is an excellent substitute for spar. The material used analysed as follows: —

	Per cent.		Per cent.
TiO_2	40	Fe_2O_3	22
SiO_2	3	FeO	27
Al_2O_3	3	MgO and CaO ..	4
Acids	46	Bases	53

Although TiO_2 is slightly acidic, it is less acid than SiO_2, and in this crude form the bases were 53 per cent. and acids 46 per cent., making a practically neutral addition. This material, when used in the same percentage as fluorspar, regularly made heats of 0.030 to 0.035 per cent. P. The slag was slightly foamy, which reduces its effectiveness, but caused only minor attack of the ladle lining.

Soda ash is an excellent flux for this mixture, but when it is used in the required amounts in the very hot steel, the fumes are obnoxious. The slag caused a rather major attack on the ladle linings. Soda ash may be used in the more open type of plant either as all or part of the fluxing addition. It has some added value as a desulphuriser.

Fluorspar produces a slag of excellent fluidity, with no pasty or foamy stage, which provides a maximum amount of surface contact between the slag and metal. After the dephosphorisation is completed, the slag has a very low melting point—between 1,090 and 1,150 deg. C. The cold slag has the characteristic stoney appearance of heavily sparred slags. The spar is passed through a steam-heated drier before the mixture is made up.

The roll scale is selected clean material of small size and is also passed through a drier.

Preparation of the Mixture

The mixture of 50 per cent. lime, 30 per cent. roll scale and 20 per cent. spar is made up in metal containers shortly before using. The ingredients are not mixed in the containers. The lime is on the bottom, the fluorspar is next, and the roll scale is on top. The roll scale is slightly damp at times and contact with the lime is avoided until time for its use. Each container holds 50 lbs. of material and any desired weight can be placed in the hopper by dumping the proper number of containers. Attempts to mix the materials in bulk for storage in large bins were not successful. The materials become separated and any dampness present causes slaking of some lime. When the containers are dumped into the feed hoppers next to the vessels a satisfactory mixing is obtained.

Ladle Reaction

The vigorous, but controlled, reaction in the ladle is a very important feature of the process. At the temperature of molten steel the reactions between slag and metal are almost instantaneous if the slag and metal are brought properly into contact with each other. The action employed in this method is a gaseous stirring promoted by the cold addition to the abnormally hot metal. The use of a molten addition to metal of normal temperature produces a milder and less effective reaction.

Experiments with this mixture added as a molten slag in an equal amount produced 0.040 to 0.050 per cent. P steel, when the blown metal was poured into the ladle in the regular manner, as compared to 0.020 to 0.040 per cent. P when the cold mixture is used. In order to produce a more vigorous reaction and obtain lower phosphorus, the blown metal must literally be dumped into the ladle in heavy surges, when using the molten material. It was found less difficult to control the reaction by chemical than by mechanical means.

The use of a cold addition produces a self-regulated ladle reaction obtained automatically with little assistance from the operators. The reaction is the same for every heat, and no boil-overs occur unless the blown metal is poured too rapidly before the reaction gets well under way.

The gaseous stirring has the effect of bringing the gases dissolved in the steel toward equilibrium and induces a very regular rimming action in the moulds. The ingots have excellent rolling quality and a first-quality product is obtained with manganese as low as 0.18 per cent. in the steel. The beneficial effect of the dephosphorising treatment on the rolling quality is used to advantage in the regular steel. The regular steel is treated with a 100-lb. addition of the mixture because of its beneficial effect on the rimming action in the moulds and the final surface quality.

The degree of phosphorus elimination is proportional to the amount of dephosphoriser used, over and above that which is required to neutralise the acid contamination experienced. The schedule for the conditions is shown in Table II.

TABLE II.—*Elimination of Phosphorus.*

Grade of steel.	Phosphorus specified (max.). Per cent.	Weight of dephosphoriser used per 6½-ton heat. Lbs.	Lbs. per ton.
GY-I ..	0.035	500	78
GY-II ..	0.040	450	70
GY-III ..	0.050	400	62
GY-IV ..	0.065	350	54

About 100 lbs. of dephosphoriser is required to neutralise the acid materials present in the company's practice and no dependable reduction in phosphorus is effected until 150 lbs. is used. The lime, roll scale, blown metal, ladle lining and stopper sleeves all contain acid materials and some contamination from small pieces of converter slag is to be expected.

Conclusions

The advantages of this method of dephosphorisation may be summed up as follows:—

(1) The controlled ratio of silicon to manganese in the iron: (*a*) permits the utilisation of a cross-section of the available Bessemer ores, rather than a few selected ores of higher cost or scarcity; (*b*) produces an ideal converter slag for slag and metal separation—the crux of the dephosphorisation operation; and (*c*) improves the quality and uniformity of regular steels.

(2) The essential ingredients for dephosphorisation are provided at lowest cost, and the extra cost of preparing a molten addition is avoided.

(3) Quality specifications for the softer grades of steel are met with regularity and uniformity.

(4) Both low-phosphorus and normal-phosphorus steels can be made in the same shop at any time with no interruptions in the operation.

(5) The advantage of a low-phosphorus steel is obtained, as well as other desirable improvements over the normal-phosphorus product.

(6) The extra cost of the method is low and the cost of differential between open-hearth and Bessemer steel is not destroyed.

(7) The product has a combination of properties of its own that is different from that of the steels made by the usual processes, which makes it valuable for certain applications.

(8) Higher ingot-to-billet yields are obtained.

(9) The application of the method requires no extensive changes in equipment and can be introduced in a Bessemer plant in a short time with no interruptions in production.

Several disadvantages and limitations of the method have developed, as follow:—

(1) Lower yields are obtained in the converting mill because of the use of iron of higher metalloid content. The loss in blowing the controlled iron is 9.75 per cent., as against about 8.5 per cent. for the normal iron of lower metalloid content. Only 3 per cent. of scrap is melted in the converters, as against 7 or 8 per cent. for the normal practice.

(2) The method is limited to the production of soft steels. Grades of over 0.20 per cent. C with 0.75 per cent. Mn are difficult to make without introducing a reladling operation.

The degree of success to be attributed to any method for the manufacture of steel should be gauged by the extent to which quality specifications are met, by the control and flexibility in operations, and by the metallurgical and economic aspects of production. It has been found that this method attains these objectives satisfactorily, and it is thought to offer a greater future for the Bessemer process.

Casting Aero-Engine Cylinder Heads*

By W. A. PHAIR

A masterpiece in sand is the complicated aircraft engine cylinder head being cast in dry-sand moulds in the new aluminium foundry of Wright Aeronautical Corp., Fairlawn, N.J. This is the only foundry in the United States owned by an aeroplane company where these heads are being successfully produced. The Aluminum Company of America produces somewhat similar heads for other aircraft companies.

The power that can be generated in an aircraft cylinder depends in a large measure upon the ability of the cooling fins to dissipate the tremendous heat generated during combustion. At one point in the evolution of the modern aircraft engine, attempts at increasing the power generated in a cylinder were held up by the problem of providing the additional cooling capacity required by an increase in cylinder power.

These narrow fins which crown the cylinder are not only important from a designer's viewpoint, but they are also important to the foundrymen for, without these fins, the casting of the heads would be a relatively simple matter. With the fins, however, the successful casting of the heads requires a nicely balanced combination of the most modern machine work and very skilful handwork.

It is no secret that before the casting of these heads was perfected, cylinder-head production was tending to hold up engine output. At the Fairlawn plant, however, this job has been perfected, and production is fast becoming a routine procedure.

These fins, which in the aggregate account for some 3,000 sq. in. of cooling surface, range from 1 to 3½ in. in height (see full-scale illustration, Fig. 1). The fins are set on $\frac{7}{32}$-in. centres and taper from 0.06 in. at the top to 0.09 in. at the point where the fin joins the main body of the head.

Moulding of the heads is accomplished in a bay, divided in two sections by an overhead conveyor. On one side of the conveyor the head cope is rammed up. On the other side the drag is produced.

In making the drag section, the fin voids are filled by hand, the sand being slung in with considerable force. Then the handwork begins in earnest with the inserting of 750 nails in between the fins to support the long fin sand core. These nails are headless finishing nails, 3 in. long by $\frac{1}{16}$ in. thick.

The flask is then set on and shovel-filled and hand-rammed. Then follows the jolt, vibrator, draw and patching. A light surface casein spray is added and the mould is placed on the conveyor to be carried through the core oven.

Some notes on equipment and foundry practice may be of interest. Match plates are aluminium and patterns are brass. All flasks are of the same size and each man devotes his entire working day to one pattern only, requiring an average of 1 hr. per mould. Lycopodium is lightly dusted on each pattern before a new mould is commenced.

In moulding, the pattern is covered to a depth of about 1 in. with a facing sand mixture of Pennsylvania glass sand and No. 80 silica sand and oil. The flask is then filled with backing sand made from a mixture of Pennsylvania glass sand, No. 80 silica sand, South Jersey moulding sand and oil. The cylinder barrel cores are also made of this last mixture. The exact proportion of each ingredient varies considerably. The moulding machines are Osborne jolt draws. The passage through the overhead oil-fired ovens to bake the mould requires 7 to 8 hrs. at a constant temperature of 220 deg. C. Leaving the core conveyor, the moulds have the cavities painted with an acetylene torch to build up a small carbon deposit, the two halves are joined, and the gate cores and pouring basin put into position and poured.

The aluminium alloy—a special Wright alloy containing copper, nickel, manganese and smaller amounts of chromium and titanium—is melted in five oil-fired Monarch furnaces of 1,000 lbs. capacity.

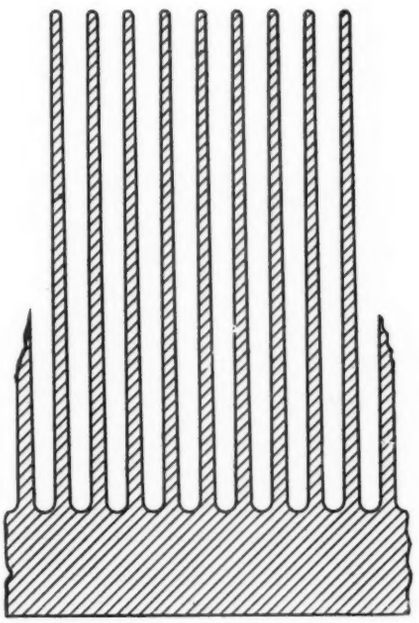


FIG. 1.—ACTUAL METAL SECTION OF AIR-COOLED AERO-ENGINE CYLINDER HEAD.

Experience has shown that the pouring temperature is a very critical factor in keeping foundry losses to a low level. For this reason extreme care is exercised in pouring only between a range of 765 and 770 deg. C. Temperature determinations are made with Foxboro pyrometers. The melting of a charge takes 90 min. in a hot furnace and 2¾ hrs. starting with a cold pot. Before pouring, chlorine gas is bubbled through the metal to remove oxides and gases, notably hydrogen. All scrap is remelted into pigs before mixing with the new alloy material.

The size of gates and risers is especially large on these heads to permit very fast pouring. The weight of the casting after leaving the mould is 70 lbs. The removal of gates, cleaning and snagging with rotary burrs cuts the weight by one-half, and the casting weighs 35 lbs. when it leaves the cleaning department. In snagging between the fins, the use of a band saw running backwards has been found effective. Preliminary cleaning takes place in a rotary sand-blast table.

After leaving the burring tables, the heads are heat-treated for 5 hrs. at 515 to 520 deg. C., followed by cooling with air blasts. This is followed by artificial ageing, a practice developed to a fine science at the Fairlawn plant. Ageing is done in Gehnrich ovens.

Immediately following the ageing operation, the castings are etched to show up cracks. In etching, castings are dipped in a solution of hot caustic soda, followed by a hot-water rinse. At this point the head is quite dark. Then, to restore a light colour, the heads are passed through a nitric acid solution and a cold-water rinse.

The heads are then subjected to a minute inspection and a Brinell test. This Brinell test is a vital factor in determining the fitness of the head. All readings must be within the range of 75 to 90 with 10-mm. ball and 1,000-kg. load.

When a cylinder head passes this point, it is as perfect a casting as human ingenuity and mechanical equipment can make it.

* Extracted from an article published in "The Iron Age."

Factors Affecting Ash Determinations in Coal and Coke

Co-operation between the British Standards Institution and the Fuel Research Board has been extended to a consideration of the factors influencing the determination of ash from coal or coke, states the Annual Report* for the year to March 31, 1939, of the Board, just issued by the Department of Scientific and Industrial Research. One of the factors that has received comparatively little attention previously, but is now under investigation, is the effect that the products of combustion of one coal may have on the ash from another when several samples of coal are incinerated simultaneously in one furnace. The problem has been noted at the Birmingham and Nottingham Coal Survey Laboratories, in particular with reference to contamination by sulphurous gases. It is known from the work at the latter laboratory that contamination can be reduced to a minimum if the rate of heating is carefully controlled, so that the temperature of the coal is raised to 400 deg. C. in 30 mins., maintained at 400 deg. C. for 30 mins., then raised to 800 deg. C., and the heating continued for one hour at that temperature. Examples showing the uniformity of results from six determinations carried out simultaneously on 1 g. portions of coal, and also the divergence introduced by the older and more rapid heat-treatment (up to 800 deg. C. in one hour, maintaining this temperature for a further hour) are given in Table I.

TABLE I.—*Effect of Rate of Heating on Determination of Ash.*

Coal.	Two-stage heating. Ash per cent.	One-stage heating. Ash per cent.
1	10.84, 10.88, 10.88, 10.82, 10.89, 10.88	10.80, 10.92, 10.94, 10.80, 10.82, 10.92
2	2.60, 2.60, 2.63, 2.60, 2.64, 2.67.	2.70, 2.78, 2.72, 2.62, 2.52, 2.54.
3	6.32, 6.39, 6.30, 6.30, 6.32, 6.34.	6.47, 6.52, 6.45, 6.58, 6.47, 6.51.

It will be observed that the slower rate of heating gives a slightly lower amount of ash with each coal; this was shown to be due to a decrease in the amount of fixation of oxides of sulphur, which was considered to be the effect of oxidising the sulphur compounds at a temperature sufficiently low to ensure relative inactivity of the bases in coal.

Excess Ash in Coke

In a Paper before the Alabama section of the American Institute of Mining and Metallurgical Engineers, J. P. Dovel stated that each 2 per cent. excess ash in furnace coke reduces blast-furnace efficiency 6 per cent., and that 10 per cent. of raw coal can be used in a blast furnace with a resulting increase in efficiency.

* H.M. Stationery Office, York House, Kingsway, W.C.2. (Price 3s. 6d. net.)

American Moulding Nomenclature

"The American Foundryman"—official organ of the American Foundrymen's Association—has recently printed a list of recommended gating terms, with appropriate explanatory diagrams. We reproduce them below with the dual object of calling attention to the confusion in terminology which exists in this country, and of helping those who have direct recourse to American foundry literature

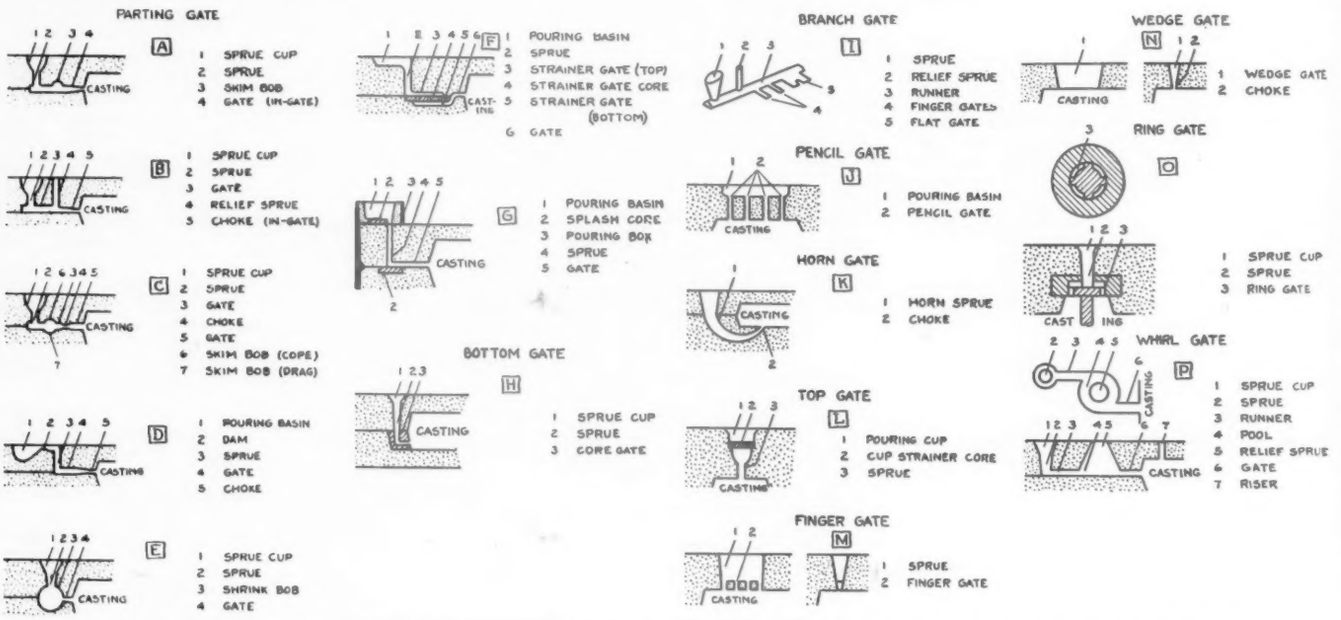
For years efforts have been made periodically to standardise the terms used in the various operations in the foundry. Colloquialisms, the use of terms indiscriminately, and often the different meanings for the same term, have added to the confusion. Foundrymen have all had the experience of listening to a discussion on a method of gating or risering and finding in the end that the speakers were talking about the same thing, but using different terms. Even the technical literature, which should be the last word in accuracy if all are to understand it, is not immune from these difficulties of interpretation due to the interchangeable use of terms.

In an endeavour to solve the difficulty, a Committee on Nomenclature was appointed by the American Foundrymen's Association, and in 1932 its sub-committee on Gating Terms brought in a report.

The report was based on a survey of the industry. Sketches of various types of gating were sent to a list of representative foundries with a request that they designate the terms that were applied to the various portions of gating systems in their plants. The replies of some 40 foundries were summarised in the report and were used as a guide by the committee in recommending nomenclature to be applied to the various parts of the different systems.

The terms recommended in the report were selected as being those most commonly used in practice and also the most descriptive. For example, the term "sprue" was selected as a proper term in preference to "down gate" and others, inasmuch as the latter term would be so similar to the recommended term "in gate." Another example is the selection of the term "sprue cup" to designate the ordinary cupped sprue mouth in preference to such suggested terms as "pouring basin," "basin," and "pouring dish," to eliminate any possibility of using a term that would be similar to the recommended term "pouring basin."

The accompanying illustration shows the nomenclature recommended by the sub-committee for the various types of gating arrangements. Those interested in the summary of the survey results will find the complete report of the sub-committee in the Transactions of the American Foundrymen's Association, vol. 40 (1932).



ILLUSTRATIONS OF NOMENCLATURE RECOMMENDED BY A.F.A. SUB-COMMITTEE FOR VARIOUS TYPES OF GATING ARRANGEMENTS.

Wanted—Brass Ingots

BY "ONLOOKER."

The recent offer made by the Ministry of Supply through the Controllers of Non-Ferrous Metals to purchase brass ingots to a fixed specification at the price of £35 f.o.r. shows that the authorities are making a laudable endeavour to tackle the problem of the accumulation of low-grade brass scrap. First reactions to the plan (for particulars of which see the JOURNAL for January 30, page 80) have probably been that the price offered is not sufficiently generous to bring much response from the foundries, who are—many of them at any rate—already engaged on priority work. The specification to which the ingot makers are asked to conform—Cu 62 to 65, Sn 0.75 to 1.5, Pb 3.5 max., Fe 0.5 max., Ni 0.5 max., Al 0.01 max., other impurities 0.5 per cent. max., and balance spelter—makes it evident that many avenues of use will be closed to this type of brass. It will be noted that the tin content is expressed as minimum and maximum, so that a melt returning a tin figure below 0.75 per cent. would presumably be unacceptable, and from this fact it would almost seem as if the Control may have some particular outlet in mind, since the presence of this amount of tin must bar these ingots from many uses.

Last year the Control made a similar gesture in regard to copper by offering to purchase at a firm price blister copper of two different grades from the refiners. What the response to this has been cannot be stated, but in spite of the fact that the specification merely called for a minimum copper content without enumerating impurities, it is not thought that overmuch business has yet resulted. So far as disposal of scrap is concerned, the situation appears to have deteriorated still more this year, at any rate in regard to those types in which copper is relatively low. The refineries are understood to be prepared to take in braziery copper, irony copper wire, etc., at the present time and to be paying fairly good prices, but there seems to be a hold-up in brass skimmings and that type of material, holders reporting that offers are much below the value of the metallic contents. Lower grade materials, such as ashes and sludge, are probably almost unsaleable. It remains to be seen whether the brass ingot scheme just launched is going to help the consumption of these low-grade materials: but many of these materials are only suitable for smelting, that is to say, valued only on the basis of the amount of copper in them.

The opinion that the price for the "Control" brass ingots is not sufficiently generous to encourage production must obviously be subject to modification in accordance with changes in the market values of various types of brass scrap. The publication of a schedule of maximum prices by the Ministry of Supply, although it was doubtless a good move, did create in some minds the erroneous impression that these listed values represented the official quotations which became in a sense minimum and maximum as well. This, combined with a belief that values of copper and spelter were destined to rise higher, brought about a market mood which resisted any downward trend, such wrongful thinking being assisted by the fact that the best grades kept right up to the maximum permitted under the order, and it is only now that the facts of the situation are really making themselves felt.

Vertical Casting of Iron Pipe

METHODS USED BY AMERICA'S OLDEST MAKERS*

By C. H. VIVIAN

One of the oldest cast-iron pipe manufacturers in the U.S.A. is the Warren Foundry & Pipe Corporation. It is one of two companies established prior to the Civil War that are still in operation. In its Phillipsburg, N.J., plant it has been making pit-cast pipe continuously since 1857—for a longer period than any other American concern can claim. It is with the Phillipsburg plant that this description will deal; but it may be mentioned here that another Warren Foundry plant, situated at Everett, Mass., and constructed in 1929, produces pipe from 4 to 16 in. dia. by means of the centrifugal casting method.

The concern was incorporated as the Warren Foundry & Machine Company on March 3, 1856, "for the purpose of carrying on general foundry business, including the casting of stoves, steam engines, mill gearing, and any or all branches of the foundry business." There was no thought at the time of manufacturing pipe. The era was one of railway expansion in its part of the country; the outlook for general foundry business was promising, and the organisers had in mind especially the making of car wheels. Twenty-five residents of Phillipsburg, of the adjacent City of Easton, Pa., on the opposite side of the Delaware River, and of neighbouring sections of New Jersey jointly agreed to subscribe $49,500 to launch the enterprise. The largest subscription was $7,000, and the smallest $500. As indicative of the success that has attended the enterprise, it is interesting to note that it has shown earnings in all but five of its 85 years of existence. With the exception of 1933, dividends have been paid continuously since 1868 and have aggregated $17,000,000.

Two Englishmen Pioneer Vertical Method

The future course of the company was determined in 1857, when it was only a year old. That was a panic year, probably the worst America had so far experienced. Early in 1857 two English foundrymen, John Firth and John Ingham, came to Phillipsburg. They knew how to cast pipe vertically. The foundry had been making pipe of small sizes in inclined moulds on a modest scale. Firth and Ingham entered into a contract to produce pipe for the company, and immediately began experimenting. By July they were casting 30-in. pipes in dry-sand moulds with success. The method was tried on the smaller sizes and worked equally well. Since that time the manufacture of cast-iron pipe has been the foundry's principal business.

The pit casting of cast-iron pipe is an interesting process. Although there have been repeated refinements in procedure and improvements in mechanical-handling equipment that have lightened labour, the fundamental practice has changed little in 90 years. The making of good pipe still depends largely upon individual skill and knowledge that have been handed down through succeeding generations. Proof of this is found in the fact that Warren Foundry retains one of its original semi-circular casting pits served by a wooden jib crane and supplied with iron from a cupola that is hoary with age. It is used for the production of tubing and odd lengths of small pipe that are turned out in relatively small lots. Some of the company's highest-class work originates there. Efforts to do it as well in modernly equipped sections of the plant have not been satisfactory. In the old pit the work seems to receive that fine touch of the moulder's art that is unaccountably lost to some extent when more refined facilities are employed. All standard pipe, however, is made in modernised shops with overhead-travelling electric cranes for handling the work quickly and with all possible mechanical aids that can be used to advantage.

All bends, tees, crosses and other fittings of necessity require a different mode of manufacture, and separate shops are given over to that work.

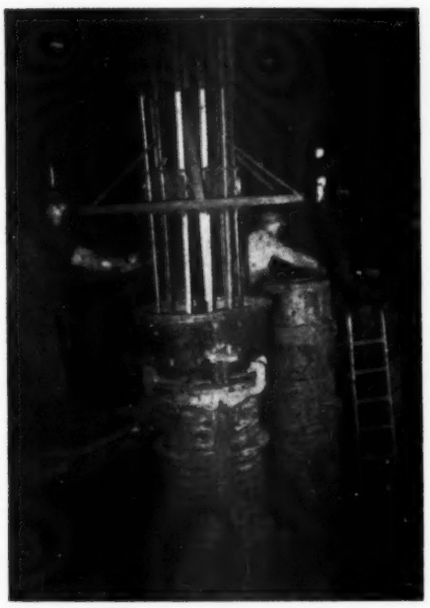


FIG. 1.—MACHINE-RAMMING OF A FLASK.

After the flared bell section at the bottom of a flask has been rammed by hand, the straight barrel section is mechanically rammed. The machine rammer has eleven tamping irons, arranged around a circle, and they are moved up and down by an arm extending from a power-driven wheel at pit-floor level. Meanwhile sand is fed from overhead through a pipe in the middle of the rammer and the flask is rotated slowly by a turntable on which it stands. The tamping irons are held by magnetic grippers that exert the desired amount of tension but permit the irons to move progressively upward as the flask fills with sand. In ramming machines for small pipes the tension on the grippers is obtained with compressed air.

Casting a length of pipe is a two-day process; the mould and the core are made one day, dried overnight, and poured the next. After a brief period of cooling, the pipe is removed from the mould, cleaned, trimmed, coated with tar, tested and marked for identification. Unless it calls for some special treatment, such as lining with cement, it may be despatched the same evening.

One of the shops is devoted to the manufacture of pipe from 14 to 60 in. in dia. Warren is one of two American foundries regularly producing pipe larger than 36 in. Running approximately half the length of this shop is a rectangular pit some 11 ft. deep. In one end of the pit the moulds are prepared; in the other end the casting is done. The cupola stands about mid-length of the building and on one side, and adjacent to the railway tracks that deliver to it pig-iron, scrap iron, coke and limestone. The other half of the structure, where there is no pit, is given over to core making and storage. On one side are core-drying ovens and a clay mill. Overhead are three travelling cranes that are principally responsible for maintaining a rate of production that pioneer pipe founders probably never dreamed could be obtained.

Pipe has a laying length of 12 ft.; but a section of the common bell-and-spigot type is made a few inches longer than that, the surplus at the spigot end extending into the bell end of the adjoining piece when they are assembled. The mould, in turn, is slightly longer than the pipe. The flask in which the former is prepared consists of two long iron members of semi-circular section hinged so as to form a cylinder when closed and held together by clamps. The foundry casts all its own flasks. Pipes 14 in. or more in diameter are made one in a flask; lesser sizes are made from two to five in a flask. The latter is delivered by crane to the rammers and stood upright at one edge of the pit, where its upper end will be conveniently accessible from the floor level above. All pipes 14 in. or more in diameter, which means everything handled in the shop referred to, are cast with the bell at the bottom. Accordingly, the flask is placed on a ramming plate, on which rests the pattern for the bell. The pattern for the pipe barrel is then lowered into the flask. It is an iron cylinder having a diameter equal to the exterior diameter of the pipe to be made. At the flask bottom it fits into and is centred by a circular opening in the ramming plate.

Ramming the Mould

The mould is then prepared by ramming sand into the annular space between the flask wall and the pattern. The bell at the bottom is rammed by hand, the lower few inches of the ramming tool being jointed so that it can reach into the flared pattern. The flask is rammed mechanically with a machine shown in Fig. 1. A few sledge-hammer blows serve to loosen the pattern from the enclosing sand. It is withdrawn a foot or two by the overhead crane, which then picks up the assembly and moves it to another position. As it is raised from the floor, the ramming plate and bell pattern are released by knocking off the clamps that hold them, and they are left behind to be used with the next flask.

When the flask has been set down in its new position, the crane removes the cylindrical pattern. Next a workman impresses in reverse in the sand wall, near to the top of the flask, identifying letters and numerals. These markings will appear in relief on the finished pipe, and include the company initial, the year, and a number showing the order of casting. The final operation consists of giving the sand wall a coat of blacking to prevent the sand from sticking to the metal after the pipe has been cast. The blacking is applied in liquid form and with remarkable expertness by a workman, who nonchalantly swings a bucket of the fluid around the interior of the cylinder with a single motion. Inspection reveals that every inch of the surface has been covered, and that scarcely any of the blacking has been left over to run out at the bottom. The base of the liquid is graphite, and in it also is sufficient clay to give the desired consistency and adhering qualities. The crane moves the finished mould into an oven, where, still standing on end, it joins others. All ovens are fired with anthracite coal.

When moulds for a prescribed number of inches of pipe have been made, the day's work of the moulders is done. Meanwhile, at the other end of the shop, another group is preparing the cores that are to be used with these moulds the next day, and its shift likewise runs until the daily quota is completed. At the same time, the moulds that were made the day before are being poured in the section of the pit that is near the centre of the long room, and as soon as that has been attended to the casters also

* Extracts from an article appearing in "The Compressed Air Magazine."

"call it a day." All these men start work before six o'clock in the morning, and the time they put in depends somewhat upon the sizes of the moulds and pipes in course of production. Ordinarily, however, they are on their way home around one o'clock in the afternoon. They work straight through the shift, partaking of food from their luncheon boxes, without even a short break from whatever they are doing.

The core is placed concentrically within the flask mould, and the metal is poured into the annular space between the two. Naturally, the diameter of the core determines the wall thickness, and pipes of the same diameter, but of different classes (that is, designed for different working pressures), have varying wall thicknesses, and the cores therefore have to be made to prescribed dimensions.

A core is built up around a core bar, which takes the form of a hollow iron cylinder cross-braced with webbing and having a centrally disposed solid bar projecting a few inches at each end. There is a cross hole in each bar through which a pin is put to facilitate picking up the cylinder by a crane. Another purpose of the extensions is to serve as bearings for the core bar so that it can be revolved while the core is being built up on it. The revolving is done by means of a mechanical drive at one end. The first step in making the core is to wrap the core bar with straw rope. The clay-sand mixture is applied as a plastic mud and in several layers. The initial coating is a thin one of clay mud that adheres well to the straw rope. This is dumped on top of the revolving cylinder from buckets and distributed over the surface by hand. A so-called loam board, its edge faced with metal, is set a prescribed distance from the cylinder to scrap off surplus mud and to control the thickness of the layer. Next a thicker coating of a coarser and stiffer clay-sand mud is put on in the same manner.

These two applications constitute what is termed the first layer, and the cylinder is then placed on a bogie truck rack with others and pushed into an oven to be skin-dried. Later it is brought back to receive the final layer of mud made of clay and fine sand. It is applied with care so that its face will be perfectly smooth, for any irregularities will be transferred to the interior surface of the pipe. The diameter of the cylinder also must be closely controlled to give the desired wall thickness to the pipe. The end that goes down in the flask is tapered slightly so that it will make a tight fit with the bell mould to prevent leakage of metal along the joint. The finished core is given a coat of blacking by hand and is placed in an oven to be dried overnight.

The next morning the respective matching flasks and cores are brought together; the cores are carefully centred by gauging to ensure pipe of uniform wall thickness, and casting gets under way. The iron is tapped from the cupola at about 1,540 deg. C. and flows into a forehearth, where a flux is added to bring impurities to the surface. These are skimmed off, and the metal is run into a ladle and transferred by crane to the point of pouring. In both the flasks and core bars are numerous perforations to permit gases to escape from the metal. This action is stimulated by the use of sufficient coarse sand in the flask and core moulds to give them porosity. After the metal has been in a flask for a short time, enough heat is transferred through the outer layers of the core to ignite the wrapping of straw rope around the bar. Owing to the absence of air it merely smoulders; but this breaks it down sufficiently to release the core bar, enabling it to be withdrawn. The rope remains embedded in the clay and bursts into bright flames as soon as air reaches it.

After the pipe has cooled to a point below red heat, the flask assembly is lifted out of the pit, laid down, and opened. The pipe is placed on a rail runway and rolled out into the yard, where workmen with pneumatic chipping hammers remove any surplus metal and smooth up rough spots. Following this cleaning, the pipe is heated and dipped in coal tar to give it a protective coating both inside and out, except when it is to be lined with cement or other material; then only the exterior is coated. Next comes the testing under hydrostatic pressure up to 400 lbs. Any leakage or sweating involves rejection. Pipes passing inspection are weighed, and their weights are painted on them. When a cement lining is specified, it is applied by a spinning process.

Offhand, it would appear that pipes of varying sizes could be made ahead of time and stored until sold. This is true to only a small extent, as most large-scale pipe purchasers want their own markings cast on the pipes and also desire their own inspectors to be present during manufacture. The same thing applies generally to fittings; but as they are special castings that cannot be produced as fast as pipe, they are stocked in moderate quantities. The centrifugal-pipe plant of the Warren Foundry and Pipe Corporation at Everett, Mass., is not equipped to make fittings; they are supplied by the Phillipsburg foundry, a sufficient stock being carried at Everett to meet ordinary demands.

There are about 460 employees in the Phillipsburg plant at present. As befits a concern of long standing, many of these workers have served for years. There are numerous father-and-son combinations among them, thus passing on the art of pipe casting to-day as it has been handed down in the past.

FIG. 2.—MAKING OF STRAW ROPE.

Each year the foundry uses from 300 to 600 tons of straw. All of it is made into rope for wrapping core bars for pipe manufacture. Formerly the twisting motion needed to make the rope was performed by a workman, who turned a tool resembling a brace and bit and having on its forward end a hook to which the rope was attached. He walked backward slowly while the ropemaker fed straw to the lengthening strand. The work was done in a long shed; and the building where the rope is now fashioned is still called the rope shed. To-day the twisting is done by a power-driven reel. The rope is made in sizes from ½ to 1 in., and is wound into spools containing about 2,500 ft. Three spools is a day's work for a ropemaker. Only barley straw is used. A year's supply is bought from farmers in southern New Jersey as soon as the threshing season is over and is stored, in baled form, in a large building adjoining the rope shed. To render it pliable for ropemaking it is wet down a day before it is used.

Publication Received

The Machining of Aluminium Alloys. Published by the Research and Development Department of the Northern Aluminium Company, Limited, Banbury, Oxon.

This publication—the first to be issued under the ægis of the new Research and Development Department—deals exhaustively with problems which have sprung into considerable prominence as a result of the great drive for increased production of machined light-alloy products. A high speed of working is a well-recognised feature of aluminium alloys, but the inherent properties of light alloys which contribute to this are often left unexplained. Consequently space has been devoted to a review of such properties as the Brinell hardness, the high coefficient of friction of aluminium on steel, high thermal conductivity, high expansibility, and relatively low notch strength—all of importance in determining the machining characteristics of aluminium alloys.

High-silicon alloys are accorded special attention, particularly with regard to the use of tools tipped with cemented carbides to obtain a high finish. The possibilities of obtaining with such alloys an accurate degree of high finish with diamond tools is also discussed. Generally speaking, the cast alloys display machining properties superior to those of alloys which have been wrought.

The latter part of the bulletin is devoted to a review of cutting tools, including lathe tools, shaping and planing tools, milling cutters, drills and reamers, saws and files. In all cases the examples and practice cited are drawn from the most modern sources. Photographs and diagrams are used to illustrate the text. Copies of the bulletin are available to our readers on application to the Research and Development Department of the issuing company at Banbury.

Contracts Open

Haslingden, March 10—Iron castings, etc., for the year ending March 31, 1942, for the Town Council. Mr. R. Taylor, borough surveyor, Municipal Offices, Haslingden.

Dewsbury, March 10—Iron castings, steel reinforcements, for 12 months from April 1, for the Corporation. Mr. Ernest Shaw, borough engineer, Municipal Buildings, Halifax Road, Dewsbury.

Royton, March 8—Iron castings, for the Urban District Council. The Surveyor, Town Hall, Royton.

Marple, March 5—Iron castings; spun- and cast-iron pipes and specials; puddled-iron tubing, I.G.E.; puddled-iron steam fittings, I.G.E., red coated; rubber insulated cables; paper insulated cables, etc., during the year ending March 31, 1942, for the Urban District Council. Mr. T. Cooper, surveyor, Council Offices, Marple; Mr. W. M. Gledhill, gas engineer, gasworks, Marple Bridge, near Stockport, and Mr. A. E. Griffiths, electricity manager, Council Offices, Marple.

The Significance of Hydrogen in the Metallurgy of Malleable Cast Iron*

By H. A. SCHWARTZ, G. M. GUILER and M. K. BARNETT

It was the original purpose to prepare a Paper dealing with the effect of hydrogen on graphitising rate. The technique of making additions of metallic elements and determining graphitising rates is pretty well understood, and the results are at least fairly reproducible and capable of quantitative evaluation. It soon became evident that a study of the effect of hydrogen is complicated by variables which require evaluation before any straightforward graphitisation programme is possible.

It will presently appear that the execution of graphitisation rate measurements in which hydrogen concentration is the only variable is so difficult that an understanding of the subject requires attention to many incidental phenomena which therefore seem to deserve investigation as much as, or more than, the narrower field originally contemplated and still far from completely investigated.

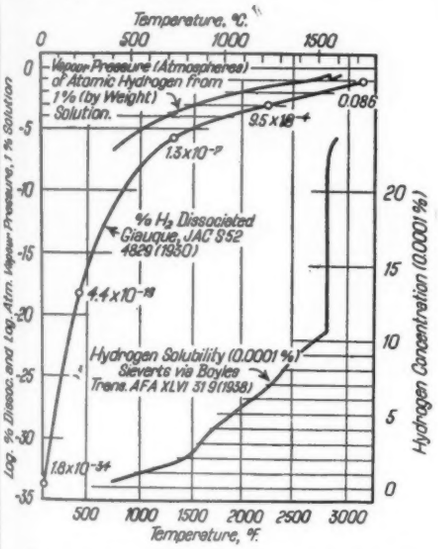


FIG. 1.—DISSOCIATION OF HYDROGEN COMPARED WITH ITS SOLUBILITY IN PURE IRON.†

Solubility of Hydrogen in Pure Iron

A diatomic gas which dissolves in the atomic state, as may be expected in the iron-hydrogen system, will have its limiting solubility determined by the degree of dissociation of the gas atmosphere (which is a function of temperature). The partial pressure of the atomic gas will, at a given temperature, be proportional to the square root of the pressure. The solubility of hydrogen in iron, as a function of temperature, is therefore meaningless unless the partial pressure of hydrogen in the atmosphere is specified.

The most commonly accepted data for the solubility of hydrogen in iron are Sievert's, *cf.* Boyles,[1] who worked under a hydrogen pressure of one atmosphere. The dissociation of hydrogen at a total pressure of one atmosphere has been critically examined by Giauque[2] on the basis of energy calculations based on spectroscopic data which should furnish the most accurate basis for conclusions on this point. Sievert's data and Giauque's are plotted in Fig. 1.

Since the dissociated hydrogen atoms occupy twice the volume of the molecular gas before dissociation, the partial pressure of hydrogen (atoms) is twice the fraction of H_2 dissociated. Assuming the validity of Raoult's law, one may then calculate the vapour pressure of hydrogen at any convenient concentration. The standard concentration is here taken as 1.00 per cent. (by weight); this is a purely fictitious value selected as a matter of convenience, and it is not implied that a 1.00 per cent. hydrogen solution in iron exists or would follow Raoult's law if it did exist.

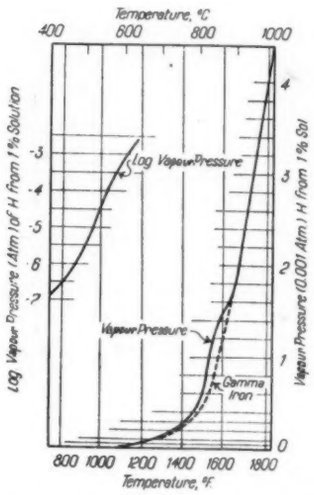


FIG. 2.—VAPOUR PRESSURE OF HYDROGEN FROM A THEORETICALLY 1 PER CENT. SOLUTION IN IRON.

Fig. 2 is an enlarged section of Fig. 1 in the region from 400 to 1,000 deg. C., and shows the calculated (a wholly imaginary) vapour pressure of hydrogen from a 1.00 per cent. solution in iron as a function of temperature on a logarithmic scale from 400 to 600 deg. C. and on a linear scale from 500 to 1,000 deg. C. The data for gamma iron are extrapolated below 900 deg. C. on the basis of a rectilinear extrapolation of Sievert's data which is not beyond criticism. One would expect to find the vapour pressure of hydrogen from a solution of given concentration to follow the Clapeyron-Clausius equation.

In Fig. 3 log. vapour pressure is plotted against the reciprocal of absolute temperature. The points for gamma iron fall well on a straight line as they should and those for alpha iron fall moderately well on another straight line. The upper left-hand point, being delta iron, should fall on a prolongation of the alpha iron line, but does not do so. Latent heats of vaporisation of hydrogen have been calculated from the slopes of the lines and recorded on the diagram.

The lines of Fig. 3 should be a better means of interpolating or extrapolating in Fig. 1 than that figure itself. The logarithmic scale is, however, too small to permit of the desired precision especially with regard to Giauque's data. The effect of calculation from two logarithmic curves is to permit inflections to exist such as are found in Sievert's curve even where no allotropic change is involved.

Determination of Hydrogen in Iron

The determination of hydrogen by the vacuum fusion method is at best unsatisfactory. Suggestions have been frequently made that hydrogen could be determined by direct combustion in a manner analogous to the ordinary carbon combustion, and Schwartz and Guiler[3] have given details of an apparently satisfactory procedure which was used throughout the present investigation.

Hydrogen Solubility in White Cast Iron

An obvious first step in any investigation of the effect of hydrogen is to determine the amount of hydrogen which white cast iron, or the malleablised product made from it, may be expected to retain at various temperatures. White cast iron, for the present purpose, when referred to without qualification may be considered to mean a material containing approximately 2.5 per cent. carbon and 1.0 per cent. silicon. Material of this character, when used as the cathode in the electrolysis of water at room temperature, in the form of strips about $\frac{1}{8}$ in. thick, current density 0.036 amp. per sq. in. for 96 hours, gains hydrogen from the atomic (nascent) element liberated at its surface till a concentration of about 0.00148 per cent.

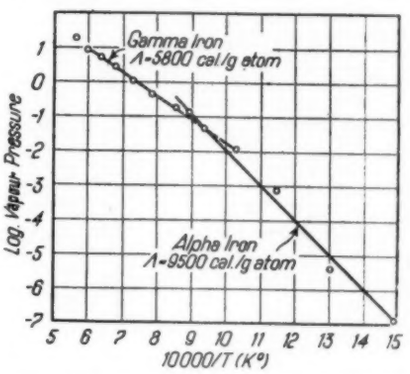


FIG. 3.—VAPOUR PRESSURE OF HYDROGEN FROM A 1 PER CENT. SOLUTION IN IRON AS A FUNCTION OF TEMPERATURE.

is reached. It is not certain that this is an equilibrium value, but the gain in hydrogen apparently is not very rapid at this time. The value is without meaning, however, for the authors cannot associate it with any particular partial pressure of atomic hydrogen.

Samples of material so enriched in hydrogen for at least 96 hrs. were crushed to fragments from 0.05 to 0.08 in. in "diameter," were heated in a very slow stream of tank hydrogen, one bubble in several seconds, at a pressure about 1 cm. of mercury above barometric in the same tube with similar samples of the unenriched iron which contained about 0.0003 per cent. hydrogen. The time of heating varied with the temperature and was so chosen that the two samples finished with approximately equal hydrogen concentrations when equilibrium was considered to be reached. Unfortunately the equilibrium value at 500 deg. C. was below the initial value.

The results of this experiment are set out in Table I.

Two facts are to be considered in interpreting the above table. Except the last sample, the iron has certainly been graphitised approxi-

* Paper presented to the American Society for Metals. Of the authors, H. A. Schwartz is manager of research, and G. M. Guiler and M. K. Barnett are research chemists, research laboratory, National Malleable and Steel Castings Company, Cleveland. Mr. Schwartz is an E. J. Fox Medallist of the I.B.F.

† Sievert's original publication is unfortunately not before the writers, and it is not known whether he measured gas volumes at room temperature or at 0 deg. C. Fig. 1 is calculated on the former supposition. If this be incorrect, then the weight per cent. of hydrogen plotted in Fig. 1 should be increased in the ratio $\frac{298}{273}$, or by about 10 per cent. The vapour pressure curve must then be dropped by 0.046, a correction not visible on the scale of the figure.

mately to equilibrium during hydrogenation and it may have become decarburised. The latter phenomenon is to be expected since it has been observed that a stream of tank hydrogen purified from traces of oxygen or moisture by bubbling through a trap containing the liquid alloy of sodium and potassium continually took up carbon (probably as CH_4) from white cast iron at temperatures as low as 200 deg. C. The stream of hydrogen in the present case did not materially decarburise the iron, being slow though therefore perhaps contaminated with CH_4. The iron after hydrogenation at 500 deg. C. contained only 0.05 per cent. carbon less (2.53 per cent.) than in its original form.

TABLE I.—*Solubility of Hydrogen in Solid White Cast Iron after Graphitisation.*

Heat-treatment.	Hydrogen content normal iron.	Enriched iron.	Probable approximate equilibrium value.	Approximate partial pressure H (Giauque).
None	0.00030	0.00148 (+)	—	—
443 hrs. at 500 deg. C.	0.00015	0.00018	16×10^{-10}	0.00016
111 hrs. at 700 deg. C.	0.00030	0.00041	20×10^{-7}	0.00030
100 hrs. at 850 deg. C.	0.00037	0.00047	4×10^{-5}	0.00042
Melted with H_2 at about 1,150 deg. C. 4 hrs. frozen in H_2	0.00150*	—	—	—

* Some hydrogen may have escaped in freezing.

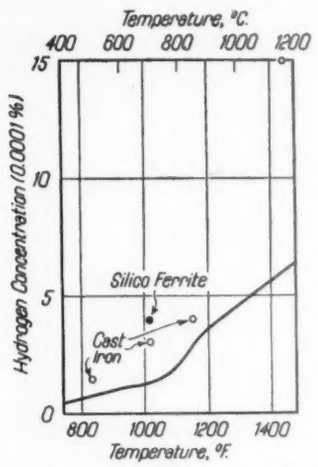


FIG. 4.—EFFECT OF ALLOYING ELEMENTS ON THE SOLUBILITY OF HYDROGEN IN IRON.

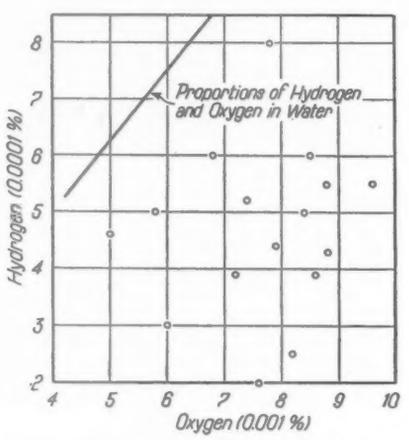


FIG. 5.—OXYGEN AND HYDROGEN CONTENTS OF COMMERCIAL WHITE IRON.

The data of Table I are compared with the curve of Sievert in Fig. 4, in which open circles represent the hydrogen content of graphitised white cast iron, the last value of the table being assigned to solid white cast iron at its (approximate) eutectic melting point. Sievert's curve applies to alpha iron between 700 and 900 deg. C.; the authors' cast irons are, of course, in the gamma state in that temperature range.

The hydrogen recorded in Table I is no doubt in part dissolved in iron (silico ferrite or silico austenite) and in part held by the graphite.

There was available a silico ferrite containing 0.02 per cent. carbon, 0.18 per cent. manganese and 0.77 per cent. silicon, and approximately 0.125 per cent. phosphorus, 0.130 per cent. sulphur and 0.06 per cent. copper. This material, in its initial condition and also electrolytically saturated with hydrogen as described above, was heated 214 hours in hydrogen at atmospheric pressure, when, regardless of starting conditions, it contained 0.00042 per cent. of hydrogen as compared with 0.00030 per cent. The silico ferrite was lower in silicon and manganese than the hard iron. One may at least conjecture that silicon increases the solubility of hydrogen in alpha iron, and manganese perhaps decreases it. The single experiment here recorded does not suggest that graphite adsorbs much hydrogen. The observation is recorded as a dot in Fig. 4.

Hydrogen Content of Commercial White Cast Iron

Schwartz and Guiler (*loc. cit.*) encountered irons ranging from 0.00018 to 0.0014 per cent. hydrogen (weight per cent.) and gave brief comments regarding the effect of certain variations in melting process. The matter may well be somewhat expanded here.

Three samples of cupola/electric-furnace duplexed malleable were available of approximately similar, but not identical, composition and produced (*a*) in the late summer under moderately moist conditions using scrap not abnormally rusty; (*b*) in the late summer under roughly similar atmospheric conditions but from very rusty scrap; (*c*) in winter under very dry conditions using scrap presumably similar to (*a*). The hydrogen content of these three samples is detailed in Table II.

TABLE II.—*Hydrogen Content of Cupola-Electric White Cast Iron in Relation to Conditions of Charge and Atmosphere.*

Atmosphere.	Scrap.	Weight per cent. hydrogen.
Moist	Normal	0.00083
Moist	Rusty	0.00115
Dry	Normal	0.00033

It is quite apparent that moisture in the air or rust in the charge increases the hydrogen content. In this case the authors cannot differentiate between a hydrogen pick-up in the cupola and in the electric furnace. There was available also a series of samples made without special selection of scrap on two wet and two moderately dry days, within an interval of a few weeks, by cupola/air-furnace duplexing in which both the cupola and air-furnace metal were sampled. The hydrogen data on this material are given in Table III.

A series of consecutive analyses (Table IV) on a single dry day, taking samples at roughly 1-hour intervals from the cupola and air furnace in a duplexing operation, is of some interest as throwing light on uniformity of results.

TABLE III.—*Hydrogen Content of Cupola/Air-Furnace White Cast Iron in Relation to Atmospheric Conditions.*

Atmosphere.	Weight per cent. hydrogen.		
	Cupola.	Air furnace.	Gain.
Dry	0.00020	0.00015	−0.00005
Dry	0.00027	0.00055	0.00028
Rainy ..	0.00070	0.00083	0.00007
Rainy ..	0.00096	0.00098	0.00002

What variations, if any, of cupola charge occasioned the decrease noted between 12.20 p.m. and 1 p.m. is unknown. There is apparently a consistent small gain in the air furnace irrespective of the hydrogen content of the cupola metal. Reference may also here be made to the statement of Schwartz and Guiler (*loc. cit.*) that "a three day average run using rusty scrap in cupola/air-furnace duplexing yielded 0.00062 per cent. hydrogen as against 0.00052 per cent. hydrogen for clean sprue."

TABLE IV.—*Hydrogen Content of Cupola/Air-Furnace White Cast Iron on Successive Samples.*

Time.	Weight per cent. hydrogen.		
	Cupola.	Air furnace.	Gain.
11.30 a.m. ..	0.00040	0.00055	0.00015
12.20 p.m. ..	0.00055	0.00060	0.00005
1.00 p.m. ..	0.00021	0.00040	0.00019
1.45 p.m. ..	0.00020	0.00030	0.00010
		Average ..	0.00012

It is of interest to include data on iron made under commercially similar conditions (with one exception, at the same time) as the above in the Brackelsberg furnace. This is done in Table V.

TABLE V.—*Hydrogen Content of Brackelsberg-Furnace White Cast Iron in Relation to Atmospheric Conditions.*

Atmosphere.	Weight per cent. hydrogen.	
	Tap.	End of heat.
Dry	0.00030	0.00060
Dry	0.00050	0.00045
Rainy ..	0.00090	0.00083
Rainy ..	0.00083	0.00094

The addition of solid metallic alloys to molten white cast iron seems to produce, in general, a marked reduction in hydrogen content. The data of Table VI are all on metal melted in the Brackelsberg furnace.

TABLE VI.—*Effect of Solid Alloy Additions on Hydrogen Content of White Cast Iron.*

Alloying element.	Nominal addition. Per cent.	Weight per cent. hydrogen.		
		Without addition.	With addition.	Loss.
Mo ..	0.23	0.0014	0.0007	0.0007
Mo ..	0.45	0.0014	0.0005	0.0009
V ..	0.16	0.0014	0.00011	0.00129
Mn ..	0.37	0.00019	0.00009	0.0001
Ni ..	0.25	0.0007	0.00045	0.00025
Ni ..	0.50	0.0007	0.0005	0.0002
Ni ..	0.75	0.0007	0.0005	0.0002
Ni ..	1.00	0.0007	0.00046	0.00024
Cu ..	0.25	0.0007	0.00055	0.00015
Cu ..	0.50	0.0007	0.00055	0.00015
Cu ..	0.75	0.0007	0.00052	0.00018
Cu ..	1.00	0.0007	0.00051	0.00019

The alloys referred to above have been investigated as to their graphitising rates,[4,5] in which investigation hydrogen concentration was not recognised as a variable.

One may note from Table VI that the very

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abnormally high concentration of hydrogen in the heat to which molybdenum and vanadium were added was very much reduced in hydrogen content by any of the additions, but notably further by vanadium than by molybdenum. The low hydrogen concentration of the heat to which manganese was added was but little reduced, and to a somewhat higher final value than accompanied the addition of molybdenum to the preceding heat. The effect of additions of either nickel or copper seemed to be largely independent of the amount of the addition. The final hydrogen concentration was of the same order as that produced by molybdenum additions to metal initially much higher in hydrogen than that used with copper and nickel. It is to be emphasised that when these specimens were first prepared the authors had neither thought nor knowledge of hydrogen concentrations, or else a single liquid metal would have been used for all the alloy additions. The somewhat meagre records since obtainable and here recorded seem to point to a tendency of almost any addition to reduce the hydrogen rapidly to roughly 0.0005 per cent. (if more was originally present), and to effect some reduction even from lower concentrations. Vanadium perhaps produces a lower hydrogen than the other elements. Perhaps one may say this of vanadium and manganese (the only active *reducing* agents in the list).

TABLE VII.—*Decrease in Hydrogen Concentration with Decarburisation of Basic Open-Hearth Steel.*

	Heat A.		Heat B.		Heat C.	
	Per cent. carbon.	Per cent. hydrogen.	Per cent. carbon.	Per cent. hydrogen.	Per cent. carbon.	Per cent. hydrogen.
Immediately after melting	0.55	0.00070	0.36	0.00080	0.55	0.00090
Before spiegel addition ..	0.24	0.00022	0.27	0.00060	0.28	0.00070
Before other additions ..	0.18	0.00004	0.22	0.00040	—	—

Relation of Oxygen and Hydrogen Content of White Cast Iron

Since rust on the melting stock is shown to increase the hydrogen content of the resulting white cast iron, and since it is also known that rusty stock increases the oxygen content of liquid cast irons, and since the dissociation of moisture in the blast yields both atomic hydrogen and atomic oxygen, one is led to suspect that in any commercial white cast iron some degree of correlation of oxygen and hydrogen content may exist. In Fig. 5 have been plotted the weight percentages of hydrogen in solid metal and of oxygen in liquid metal, on a series of samples. The oxygen content is calculated from the Al_2O_3 formed when a large excess of aluminium is added to liquid iron and is probably an accurate determination of the oxygen content of the liquid. It cannot be said with certainty that this amount would survive in the frozen metal had it not been fixed by the addition of aluminium. Since foundry irons do not blow, it seems likely that the comparison in Fig. 5 is reasonably justified.

As might be expected in view of the free oxygen and CO_2 of the flame, the oxygen content of the iron is always more than eight times the hydrogen content as would be the case had the liquid metal merely absorbed the dissociation products of water. It is apparent that there is no close correlation of hydrogen and oxygen content of liquid metal, but some trend toward high oxygen accompanying high hydrogen, and *vice versa*, can be detected. The slope of such a trend line might not be far from that corresponding to the ratio of the two elements in water.

It must not, however, be assumed from Fig. 5 that, regardless of history and origin, a high oxygen content implies a high hydrogen content. The degree of oxidation incident to the decarburisation of basic open-hearth steel is accompanied by a radical decrease in hydrogen content, as shown in Table VII. This is as it should be in view of the FeO-C and FeO-H equilibra.

Hydrogen Content of Annealed White Cast Iron

From the experiments on the solubility of hydrogen as a function of temperature, it is to be anticipated that most white cast iron is supersaturated with hydrogen at partial pressures of hydrogen such as might be expected to exist in heat-treating atmospheres where the hydrogen concentration is determined by the rather small dissociation of water vapour either from atmospheric moisture or from the combustion of fuel containing hydrogen.

In Table VIII are recorded the hydrogen contents of white cast irons produced in seven consecutive working days, together with the hydrogen contents of the same metal after commercial annealing to malleable cast iron and the loss of hydrogen. The figures of Table VIII are to be interpreted as average values for the days in question.

TABLE VIII.—*Hydrogen Content of Unannealed and Annealed White Cast Iron.*

Weight per cent. hydrogen.		Weight per cent. hydrogen.	
Hard.	Malleable.	Hard.	Malleable.
0.00046	0.000125	0.00085	0.000115
0.00052	0.000085	0.00060	0.000155
0.00050	0.000130	0.00058	0.000140
0.00064	0.000050		
	Average	0.00059	0.00013

The great decrease to a value approximately independent of the initial hydrogen content is noteworthy.

(To be continued.)

A Permanent Mould for Lifters

BY JAS. TIMBRELL.

Wrought iron for "gaggers" and "straights" for use in coremaking, hitherto considered a necessity in the foundry, has now become more or less of a luxury. Because of this, the arrangement shown in Fig. 1 for making assorted cast-iron lifters and lengths of straight rod will be of interest. In this case four permanent moulds, A, B, C and D, were provided; two were designed for the most commonly used lifters, and two for lengths of rod.

The moulds are bolted on to the two rotating members, E and F. The shape of the shaft and bearing (inset G, Fig. 1) provides easy rolling-over by the hand levers H, and the flats J come to rest with a permanent mould on top, level, for pouring. The assembly (shown in pieces) is from unmachined castings. The two side columns K and the baseplate L are bolted together in bearing line and fixed level, and each of the four permanent moulds—invariably kept level—are then attached in turn. Any out-of-level discrepancy is taken up by packing pieces placed between the faces M.

The unit should preferably be placed handily alongside the cupola spout or near to a shank service point, as this arrangement allows of small quantities of returns being used up for pouring rods or lifters. A sprinkling of fine coal dust on the moulds prior to pouring will ensure the smaller-section rods running true to shape.

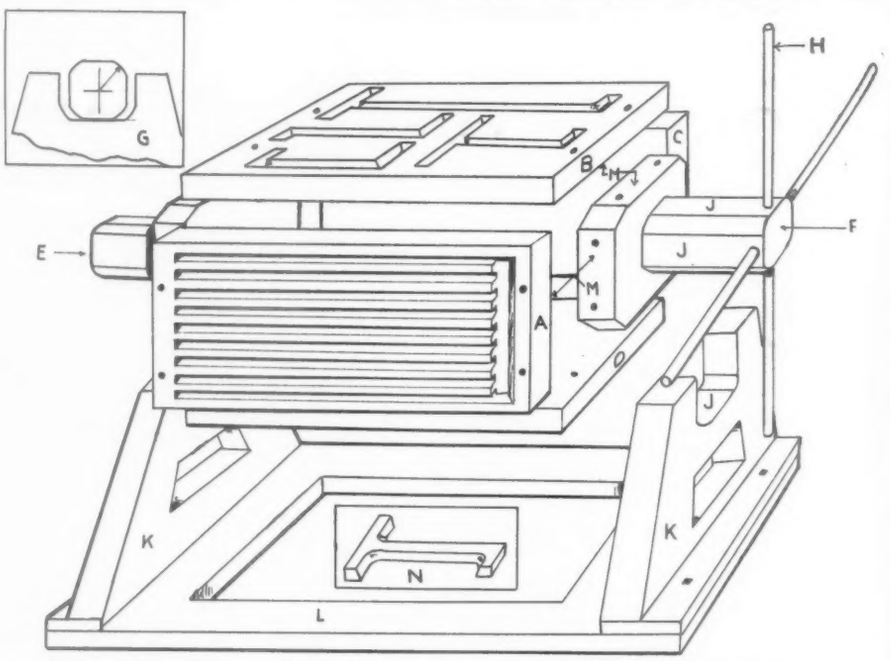

FIG. 1.—PERMANENT-MOULD CASTING DEVICE FOR CAST-IRON LIFTERS AND ROD.

Wrought-iron lifters and rods offer some degree of permanency in certain shapes and sizes, their main disadvantage (amongst others) being the difficulty experienced when opening the cast-up moulds, as the lifters have to be levered clear of the moulding-box bars. Again, in coring out heavy castings during fettling, wrought iron has to be completely free before it can be removed. On the other hand, cast-iron lifters can be broken off progressively as soon as they become an obstruction in the fettling out, etc.

Inset N shows a type of profile or "leave" which will "contract" itself free from the mould on rolling face downwards after pouring.

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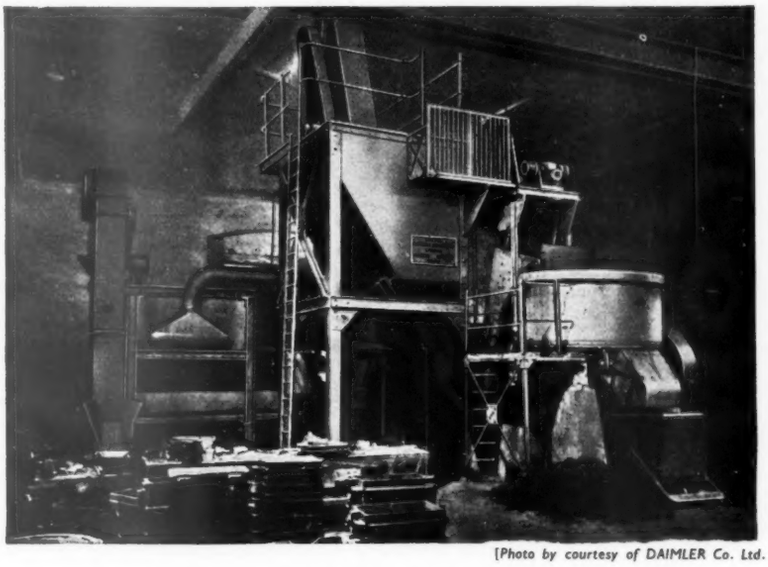

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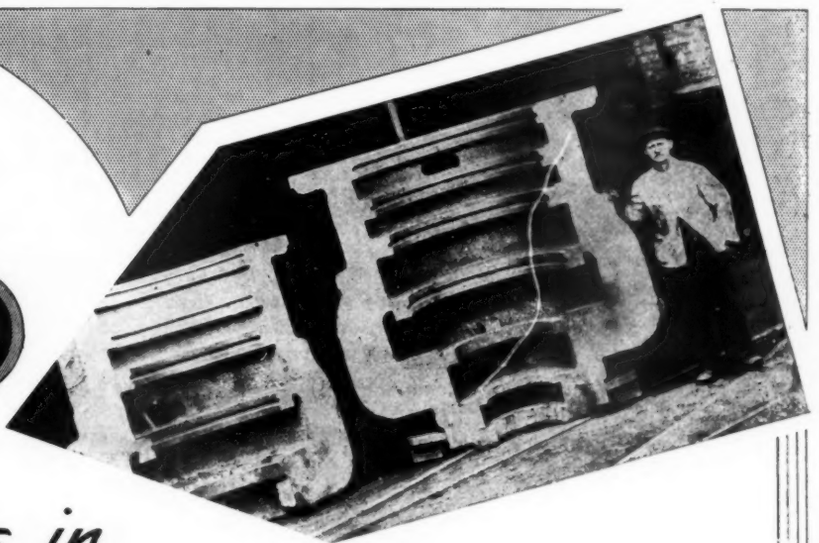

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The Week's News in Brief

Trade Talk

OVER EIGHTY new members were elected at the February meeting of the Council of the Newcomen Society.

THE MINISTER OF AIRCRAFT PRODUCTION acknowledges with gratitude the gift of £3,000 from non-ferrous scrap metal merchants of Great Britain towards the purchase of aircraft.

THE WOMEN'S ENGINEERING SOCIETY, 20, Regent Street, London, S.W.1, is launching an appeal for funds to commemorate Amy Johnson's brilliant career as an air pilot, by the foundation of a scholarship for women in aviation.

THE CZECHO-SLOVAK SKODA works are reported to be concentrating their whole production on anti-aircraft guns for Germany. Hitherto the works have been engaged on export orders, but operations in this direction have been dropped.

PRODUCTION of the Indian Iron & Steel Company, Limited, in the period October to December, 1940, was: Pig-iron, 200,409 tons; coke, 195,153 tons; iron castings, 15,313 tons. The furnaces at Hirapur and Kulti, it is stated, are working to capacity.

THE ENTIRE RESERVE OF 226 tons of tungsten held by the U.S. Navy has been released by the authorities to the steel industry to relieve a temporary shortage in the production of high-grade steel for armaments. Further supplies are expected from China over the re-opened Burma road.

FOUR YEARS' CONTRIBUTIONS by workpeople of Hale & Hale (Tipton), Limited, resulted in Walsall General Hospital receiving the last of £750 to endow a bed in the children's ward. The gift by the firm's principals—Councillor W. E. Hale and Mr. T. Hale—of this £9,000 ward led their workpeople to decide to raise moneys to endow cots for it. Weekly collections began at the ironfoundry in December, 1936.

THE BRITISH ALUMINIUM COMPANY, LIMITED, whose temporary head office is at Oakley Manor, Belle Vue, Shrewsbury, Shropshire, announce the following changes in branch office addresses: The Birmingham office is removed from Lawley Street to Lansdowne House, 41, Water Street, Birmingham, 3 (telephone, Central 3053-4). The Bristol office and warehouse are closed temporarily. The London office is removed from Norfolk House to Trafalgar House, Waterloo Place, London, S.W.1 (telephone, Abbey 1365).

THE INTERNATIONAL MEEHANITE METAL COMPANY, LIMITED, has recently granted licences to manufacture Meehanite Metal to Qualcast, Limited, of Derby, and Gould's Foundries, Limited, of Cardiff and Newport, Mon. In South Africa, the subsidiary company, The Meehanite Metal Company (S.A.) (Pty.), Limited, of Johannesburg, has now established the process in the works of four firms, namely, The East Rand Engineering Company, Limited; Wright-Boag & Company, Limited; Thos. Begbie & Company; and the Umgeni Ironworks.

MR. ANGUS L. MACDONALD, Dominion acting Minister of Munitions and Supply, has indicated that further control measures will be taken in order that Canada will have adequate supplies of steel both for defence purposes and for more urgent civil needs, since the indicated consumption of steel in 1941 is some 50 per cent. more than the total capacity of the industry. Many steps have already been taken to offset the shortage. Arrangements have been completed whereby extensive additions both to blast furnace and melting capacity will be completed before the middle of the year. Over £1,000,000 is to be spent on additions to an electric alloy steel plant which will be in operation about June. The 1941 needs will also be met in part by domestic supplies of scrap, apart from a curtailment of steel used for civil purposes. The Canadian Steel Controller has recently completed arrangements with the U.S.A. for the export to Canada of a large quantity of scrap.

THE Federation of British Industries has put before the Chancellor of the Exchequer points outlining the serious results to manufacturing industry which, in its view, must follow in the absence of some substantial modification of the Excess Profits Tax. In suggesting possible modifications in the tax, the Federation particularly emphasises that it has dismissed any suggestions which would result in rendering more money available for general distribution—for example, in dividends. Briefly, the Federation suggests that the rate of duty be reduced to 80 per cent., but with the proviso that the balance of 20 per cent. must be retained in the business or applied only to such restricted purposes as the Treasury may see fit to allow. Such purposes should include capital expenditure, payments under the War Damage Bill, and additional income-tax payable as a result of a reduction of E.P.T. from 100 per cent. to 80 per cent. In addition, detailed suggestions are put forward to the Chancellor's advisers on the subject of capital expenditure and its reimbursement, the computation of capital, deferred repairs and renewals, contributions under the war damage schemes, stock valuation, and the replacement of air-raid shelters.

Personal

MR. C. S. BELL has retired from the board of Turner & Newall, Limited.

MR. E. M. CURRIE some time ago accepted an invitation to join the board of directors of the International Meehanite Metal Company, Limited.

BRIG.-GEN. G. M. JACKSON has this month completed 50 years' connection with the Clay Cross Company, Limited, of which he is chairman and managing director.

MR. W. A. STANIER, chief mechanical engineer of the London Midland & Scottish Railway, on Friday last was elected President of the Institution of Mechanical Engineers.

MR. SYDNEY A. SMITH has been awarded by the Council of the Institute of Marine Engineers the Denny Gold Medal for 1940 for his Paper on "Marine Steam Turbine Design."

MR. S. J. HAWES, warehouse foreman in London for O'Brien, Thomas & Company, Limited, the Rotherham firm of ironfounders, has been the recipient of a presentation on his completion of 50 years' service.

MR. CHARLES LAWRENCE BURNS, who has been with Scott Brothers, Limited, iron and steel merchants, Newcastle-upon-Tyne and Middlesbrough, for 21 years, during the past ten years as manager of the Newcastle branch, has recently been made a director of the company.

MR. MATTHEW BROWN, managing director of the Shotts Iron Company, Limited, was presented with gifts, on the occasion of his retirement, at a function in Edinburgh last week. The gifts, which were handed over to Mr. Brown by Mr. John Duffy, who had been in the service of the company for 63 years, consisted of a writing bureau, a set of gold cuff links, and a wallet of Treasury notes, while Mrs. Brown received a string of Scottish pearls. Mr. C. Augustus Carlow, a director of the company, presided.

Will

CHICHESTER, SIR EDWARD GEORGE, of Instow, Devon, a director of the Wallsend Slipway & Engineering Company, Limited, and other companies £10,489

Reports and Dividends

Evered & Company, Limited—Net profit for 1940, £23,532 (against £23,236); dividend of 10 per cent. (same).

Beans Industries, Limited—Final ordinary dividend of 27½ per cent., making 37½ per cent. for the year ended November 30 last.

Crosthwaite Furnaces & Scriven Machine Tools, Limited—Profit for 1940, after providing for depreciation, employees' bonus, and taxation, £4,184; brought in, £3,370; dividend of 10 per cent., £2,448; bonus of 5 per cent., £1,224; to general reserve, £500; carried forward, £3,382.

Short Bros. (Rochester & Bedford), Limited—Trading profit for the twelve months ended August 31, 1940, £253,700; net profit, £103,700; available with amount brought in, £142,915; to general reserve, £25,000; staff pensions, £5,000; to preference share redemption fund, £5,250; dividend on the 5 per cent. redeemable cumulative preference shares, £12,207; dividend of 27½ per cent. on the "A" ordinary and ordinary shares, £57,151; carried forward, £38,285.

Obituary

MR. ARTHUR CLARKE, who carried on business as a metal merchant at West Hartlepool, has died.

SIR WALTER HERBERT COCKERLINE, well-known shipowner and industrialist, died at Scarborough recently. He was 85 years old.

MR. EDGAR O. BOLTON, a director of the Lancashire Foundry Coke Company, Limited, has died. He was a Past-President of the Lancashire and Cheshire Coal Association.

MR. KENNETH FRASER, vice-chairman and managing director of the Yorkshire Copper Works, Limited, Leeds, died on February 17, aged 67. Mr. Fraser was born at Stockton-on-Tees and was trained for a commercial career with the Stockton Malleable Iron Company, Limited (now part of the South Durham Steel & Iron Company, Limited), and then took part in the management of Elliott's Metal Company, Limited, Birmingham. He went to Leeds in 1907. Mr. Fraser rendered notable services to the National Savings movement in Leeds.

WE REGRET to announce the death of Mr. James Laing, foundry manager of John Hall & Son (Oldham), Limited. Mr. Laing became prominent as a writer on non-ferrous foundry practice; and in most of his work he had the good fortune to collaborate with Mr. R. T. Rolfe, the metallurgist. This combination of theory and practice resulted in the production of a series of books which are highly esteemed by all sections of the industry. Mr. Laing held positions at Luton and Deptford before going to Lancashire, and everywhere he made a host of friends. He joined the London Branch of the Institute of British Foundrymen in 1933 and both there and later in Manchester he was active both in the presentation of Papers and in discussion. Only recently he was awarded the Institute's Diploma for a Paper on "Gating and Pouring Temperatures in Non-Ferrous Foundry Practice."

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Youlgreave Mines & Fluor Refinery, Limited, 55, Norfolk Street, Sheffield—Capital, £2,000. Directors: R. E. and R. S. Horrox.

H. Tinsley & Company, Limited, Werndee Hall, South Norwood, London, S.E.25—Capital, £10,000. Telegraphic and scientific instrument makers, etc. Directors: D. C. and G. F. Gall.

Hughes Lathbury, Limited, 4, Colmore Row, Birmingham, 3—Capital, £3,500. Patternmakers, die sinkers, etc. Directors: E. Hughes, A. M. Hughes, and M. E. M. Eldershaw.

Bailey & Mackey, Limited, 173, Great Hampton Row, Birmingham—Capital, £4,000. Brassfounders, manufacturers of door and window fittings, etc. Directors: A. W. French, R. N. Houston, H. V. Bailey, and H. Beasley.

J. C. Gregory & Son, Limited—Capital, £10,000. Importers of and dealers in cryolite, felspar, fluorspar and quartz, stone crushers, etc. Directors: M. S. O'Brien, 17, Grosvenor Road, Newcastle-under-Lyme, Staffs; R. A. Skerratt.

Morley Bros. (Ironfounders), Limited, Hyde, Ches.—Capital, £10,000. Directors: A. Morley, J. Arstall and J. K. Arstall.

Alliance Casting Company, Limited, 544, Harford Street, Birmingham—Capital, £5,000. Directors: O. Deutsch, R. Brenner, and V. Brenner.

J. Hickey & Sons, Limited, 123, Sandycombe Road, Richmond, Surrey—Capital, £30,000. Manufacturers of and dealers in boilers, furnaces, tubes, etc. Directors: A. and J. B. Hickey.

Forthcoming Events

MARCH 5.

Institute of Metals:—Thirty-third annual general meeting, in London, at 2.30 p.m.

Manchester Metallurgical Society:—"Gas Heating in Connection with Metallurgy," Paper by C. M. Walter, in Manchester, at 6.30 p.m.

Institute of British Foundrymen

MARCH 8.

Scottish Branch:—Annual general meeting, followed by a Paper by Dr. J. W. Donaldson, in Glasgow, at 3 p.m.

West Riding of Yorkshire Branch:—"Non-Ferrous Practice, with Special Reference to Light Alloys," Paper by N. C. Ashton, in Bradford, at 6.30 p.m.

MARCH 15.

East Anglian Section:—Annual general meeting. "Precautions to be Taken in the Production of Sound Malleable Iron Castings," Paper by V. N. Wood, in Ipswich, at 3.30 p.m.

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Raw Material Markets

Ever-increasing pressure on the iron and steel productive capacity by various Government departments is not making conditions easier for ordinary domestic consumers; on the contrary, these buyers are encountering more and more difficulty in obtaining their requirements—but, of course, it is imperative that war needs take pride of place in the allocation of supplies. Home output of certain descriptions is, in fact, insufficient to satisfy urgent demands, and considerable tonnages of imported material are having to be used. Foundrymen manufacturing heavy castings are participating fully in Government defence projects, while a larger amount of official work is now being done by the light-castings trade, although this section is by no means employed to capacity.

Pig-Iron

MIDDLESBROUGH — Practically the whole attention of local ironmakers is devoted to the production of steelmaking iron, the output of Cleveland foundry iron being intermittent and representing a negligible proportion of the requirements of consumers, who are drawing on the outputs of makers in the Midlands. Thus, to all intents and purposes, the Cleveland foundry iron trade, which formerly supplied users over a wide area, including Scotland, has temporarily been closed down. Producers in the Midlands are able to deliver satisfactory supplies, however, and prices leave North-East Coast buyers at no disadvantage. Heavy engineering establishments are working to capacity on wartime contracts, but the position of the light foundry trade, though much improved, is still unsatisfactory in so far as works could readily accept a much greater volume of orders.

Demands on the local output of hematite are in excess of the supply, so that it is incumbent on users to utilise other grades of iron where practicable. Where home sources of supply have failed, high-priority users are able to purchase supplies of imported material from the Control, who will only release the expensive foreign iron to meet urgent calls from users engaged on Government work. On the whole, supplies are moving a little more freely, due to improved transport facilities.

LANCASHIRE—Demand for Midland brands of foundry pig-iron is maintained at a high level, and deliveries are coming to hand steadily, with the prospect of improvement in the near future. Heavy engineers are very active, and have order-books filled for as far ahead as they care to go at the present time, Government departments maintaining a steady flow of delivery specifications. Light-castings makers, on the other hand, are mostly still seeking further employment, despite recent improvement in business, especially on Government account. The situation among jobbing foundries is variable, some concerns being busy, while others are rather quiet. Some of these foundries are concerned at the inadequate supply of skilled labour for their shops.

MIDLANDS—Compared with other grades of iron, the supply of high-phosphorus material is comparatively free, some users having been able to accumulate stocks. It is necessary, of course, to procure purchase licences from the Control, as in the case of other descriptions, but the authorities are as eager for consumers to build up limited reserves as are the users themselves. High-phosphorus iron, produced from home ores, is used largely by the light foundry trade, with a certain quantity in demand by the heavy engineers. The latter, however, consume mainly low-phosphorus iron and hematite, home output of which has been curtailed of late. The Control has therefore had to import substantial tonnages of these grades, and considerable discretion is exercised in distribution of foreign material. Heavy engineers are at times able to incorporate refined iron in their mixtures, supplies of this grade being fairly free.

SCOTLAND—There is a very strong demand for pig-iron from the heavy engineering trade, which is chiefly engaged on contracts of national importance. Urgent requirements are being dealt with, and no user in the high-priority category is allowed to be handicapped by non-delivery of iron. Only current needs can be met, however, much as users would like to lay down reserve stocks. The light-castings trade is busier than it has been for a long time past, but this branch is by no means operating to capacity and is hoping for a still larger share of Government orders. Iron for this trade is forthcoming from the English Midlands satisfactorily. Deliveries of raw materials to local steelworks are maintained, current requirements being at a very high level.

Coke

While the export trade in foundry coke remains very quiet, business with home consumers is at a gratifying level, and large tonnages are being taken up. The ovens are easily able to cope with all requirements and are maintaining considerable stocks at consuming points. For delivery to Birmingham and Black Country stations, the price of Durham best foundry coke remains at 61s. 6d. per ton, minimum, but this figure is subject to change at any time.

Steel

Practically all branches of the steel industry are obtaining ready disposal of their outputs. Consumption in connection with Government contracts is very heavy, and is likely to be fully maintained over a considerable period. Heavy engineering establishments and shipbuilders and repairers are pressing for all the steel suitable for their requirements they can acquire, and it is to consumers such as these that priority is accorded in the matter of deliveries. While the bulk of current business in steel is with home users, a certain volume of export trade is being carried on; overseas trade is mainly concerned with the Dominions and Colonies, and the steel sent abroad is usually to help meet some part of the Empire's contribution to the war effort.

Scrap

It is felt that much more demolition scrap could be made available promptly if the necessary powers for its collection were utilised, and unless improvement is noted in this respect it is probable that the authorities will compel parties concerned to place this valuable material at the disposal of the consuming works. The pressure for iron and steel scrap is strong, and larger quantities of certain grades would readily be taken up were they available. Thus, there can be no slackening of efforts to bring forward all supplies. During recent weeks imports of scrap have been at a lower level, and the strain on home sources of supply has consequently been increased.

Metals

Tin—Spectacular rises were recorded each day last week in tin quotations on the London Metal Exchange, but the upward movement was checked on Monday, when the price of cash tin declined 70s. per ton and three months 65s. The peak was reached last Friday, the cash quotation on that day being £282 10s. to £283 10s. The threat of Japanese interference with tin shipments was, of course, the cause of the trading activity. During last week there was a brisk demand for spot metal, but sellers showed reluctance to dispose of their stocks, as was indicated by the declining turnover during official hours of business. On Friday sales at 250 tons compared with 300 tons on the previous day and 425 tons on Wednesday. The present week opened on a quieter note, sales on Monday being down to 100 tons and it was evident that views on the outlook in the Pacific were less pessimistic. On Tuesday 250 tons changed hands.

It has been announced that the United States National Defence Commissioners have decided to entrust the operation of the proposed tin smelter to the Billiton Tin Company, the Dutch concern, but the location of the smelter is as yet undecided.

Referring to the tin restriction scheme at the annual meeting of Malayan Tin Dredging, Limited, on Friday, Mr. C. V. Stephens (chairman) said that production of tin had been subject to official control for some 10 years, and during that period regulation of production had had a fairly exhaustive trial. He thought it would be conceded that the scheme, notwithstanding various inequalities, had proved sufficiently elastic in working to have overcome the difficulties with which it had had to contend and to have fully justified its existence. Looking back one could say that co-operation had proved of real value to producer and Government alike. Many who at one time resented the introduction of any form of regulation had come to realise that the fruits of co-operation were far preferable to the results of cut-throat competition, and were now ardent supporters of the control of production. The present agreement was due to expire in December next, and though one did not know what the future might have in store one could only express the hope that it would be found possible to renew the scheme for a further period on a basis that would be acceptable and would do justice to the legitimate claims of all countries supporting the regulation of production. Speaking of the present position of tin, Mr. Stephens said that production, according to some market authorities, was at present running at the rate of about 90,000 tons yearly above actual consumption, excluding the purchase of 75,000 tons for the U.S.A. war reserve stock, which was likely to be completed within the next four months. There were rumours current that the U.S.A. would decide to increase their reserve stock over and above 75,000 tons, but unless that happened a drastic cut in the permissible quota would become necessary from about July next if production and consumption were to be brought on a reasonable level with one another.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £279 to £279 10s.; Friday, £282 10s. to £283 10s.; Monday, £279 to £280; Tuesday, £276 to £276 10s.; Wednesday, £270 to £270 5s.

Three Months—Thursday, £275 to £275 10s.; Friday, £276 15s. to £277; Monday, £273 10s. to £274; Tuesday, £272 5s. to £272 10s.; Wednesday, £267 10s. to £267 15s.

Copper—Supplies of this metal for war work are quite satisfactory, and no shortage is anticipated in connection with Government requirements. Other consumers, however, are going short and are experiencing considerable difficulty in obtaining sufficient metal to meet even a proportion of their needs. While the supply situation in the United States remains rather tight, additional metal should shortly be forthcoming from South America, and prospects over the year are not unsatisfactory.

Spelter—Brassmakers are taking up very considerable tonnages of high-grade metal, while galvanisers are using g.o.b. metal on a heavy scale. Defence requirements account for the bulk of the metal available for distribution, and there is little to spare for consumers outside Government lists.

Lead—No inconvenience is felt in connection with supplies of lead, and both essential and non-essential demands are being easily met. In view of the present Japanese attitude, however, it is possible that the Control will exercise more caution in making allocations as a precaution against possible interruption of shipments from Australia, which, in 1938, supplied the United Kingdom with nearly 189,000 tons of her imports of 407,000 tons.

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